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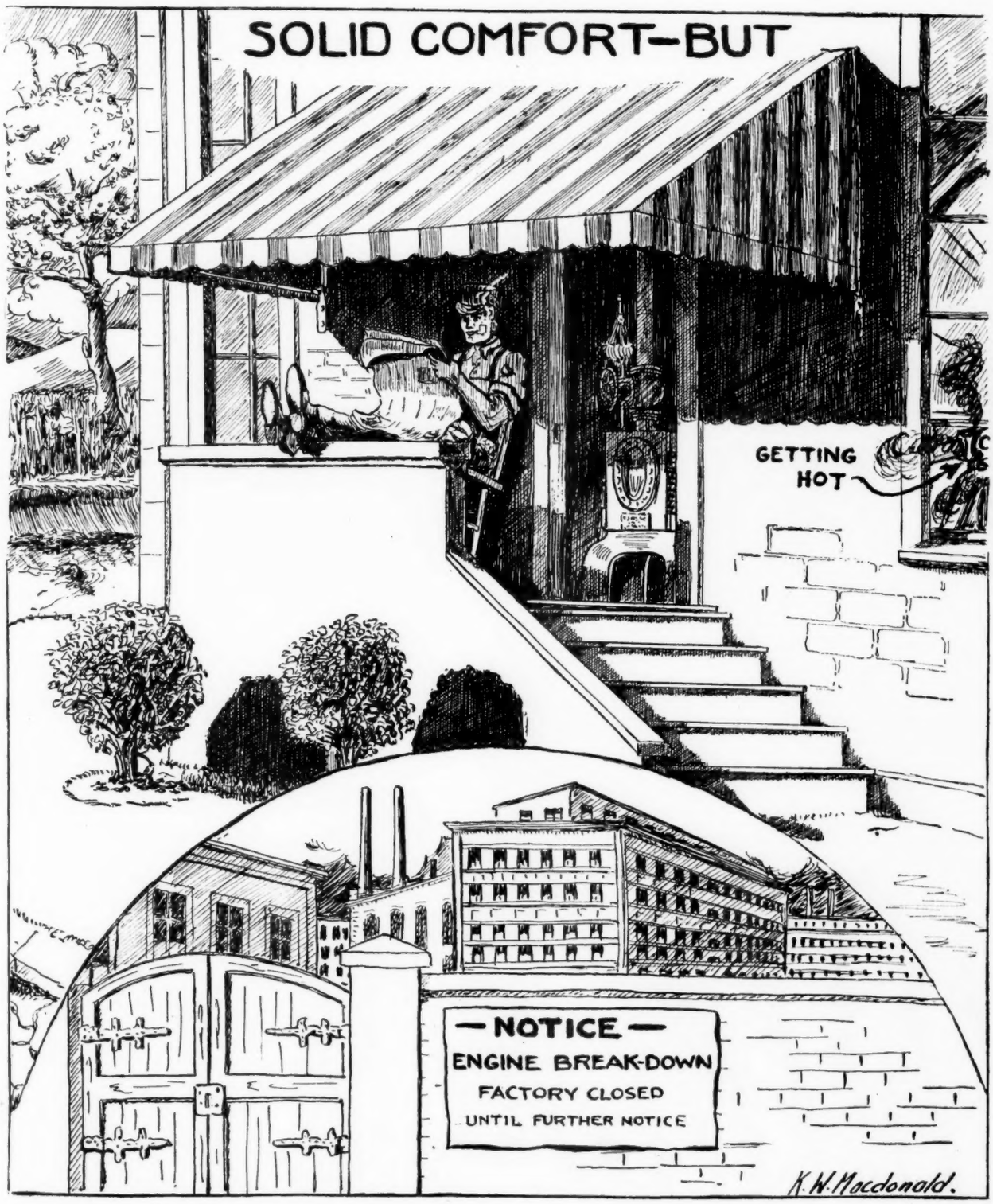
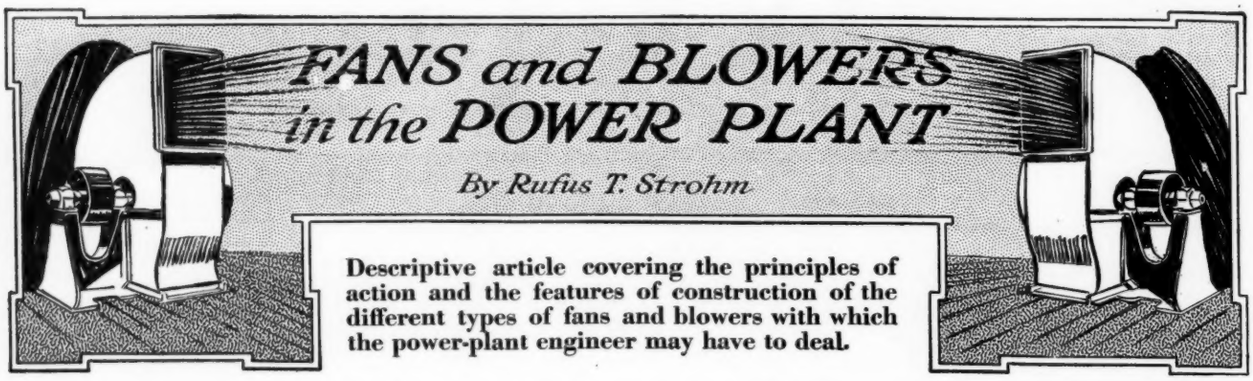




FANS and BLOWERS in the POWER PLANT

By Rufus T. Strohm

Descriptive article covering the principles of action and the features of construction of the different types of fans and blowers with which the power-plant engineer may have to deal.

SUCH requirements as the production of forced or induced draft, the ventilation of rooms or buildings, the removal of gases or light refuse from workshops or factories, and the furnishing of quantities of air for drying or heating in manufacturing processes necessitate the use of fans and blowers, and the equipment for rendering these forms of service is ordinarily in charge of the engineer of the power plant.

The type and design of the fan or blower will depend on the duty it must perform. For example, it may have to supply a small volume of air at high pressure or a large volume of air at low pressure; it may have to force the air through pipes or ducts, as in ventilating systems; or it may discharge the air freely into the atmosphere, as in the case of exhausting foul air from a mine.

Fans may be divided broadly into two classes; namely, centrifugal fans and disk fans. A centrifugal fan is one that causes the air to move by subjecting it to the action of centrifugal force. The type of fan shown in Fig. 1 acts on this principle. It consists of a number of flat blades *A* arranged radially around a driving shaft *B* and held to it by arms *C*, the whole being inclosed in a casing *D* that is open at the center, forming the inlet *E*, and that has a discharge opening at *F*.

The shaft *B* is rotated by a belt and pulley or by a direct-connected engine or motor. As the blades *A* sweep around inside the casing they carry the air around with them, and as the air has weight, the rotary motion sets up centrifugal force that throws the air outward. The movement of the air away from the shaft causes a partial vacuum at the center of the fan wheel and a corresponding increase of pressure at the tips of the blades. As a consequence, the air that is thrown outward against the casing escapes by way of the discharge outlet *F* while at the same time air enters through the central opening *E* to fill the partial vacuum formed around the shaft. There is thus set up a continuous flow of air inward at the center and outward at the discharge opening.

A disk fan is shown in Fig. 2. It consists of a number of radial blades *A* fastened to a central driving shaft *B* but set at an angle to the shaft, as in the familiar windmill. A narrow casing *C* surrounds the fan. When the shaft *B* is rotated, air is drawn into the fan at one side and discharged at the other, in a direction parallel to the shaft. In this respect it differs from the centrifugal fan, which discharges the air at right angles to the shaft.

The disk fan, while simple in construction, is not adapted to work against much resistance. It simply propels the air and is unable to build up any considerable pressure on the discharge side. The reason is that there is so much opportunity for leakage of air back through the revolving blades, particularly at the center of the wheel, where the linear velocity of the blades is small. Both the inlet and the discharge should be free and unconfined. Accordingly, the disk fan is used in the ventilation of offices, workrooms, engine and boiler rooms, kitchens, restaurants and the like. The fan is commonly set so as to fit closely an opening

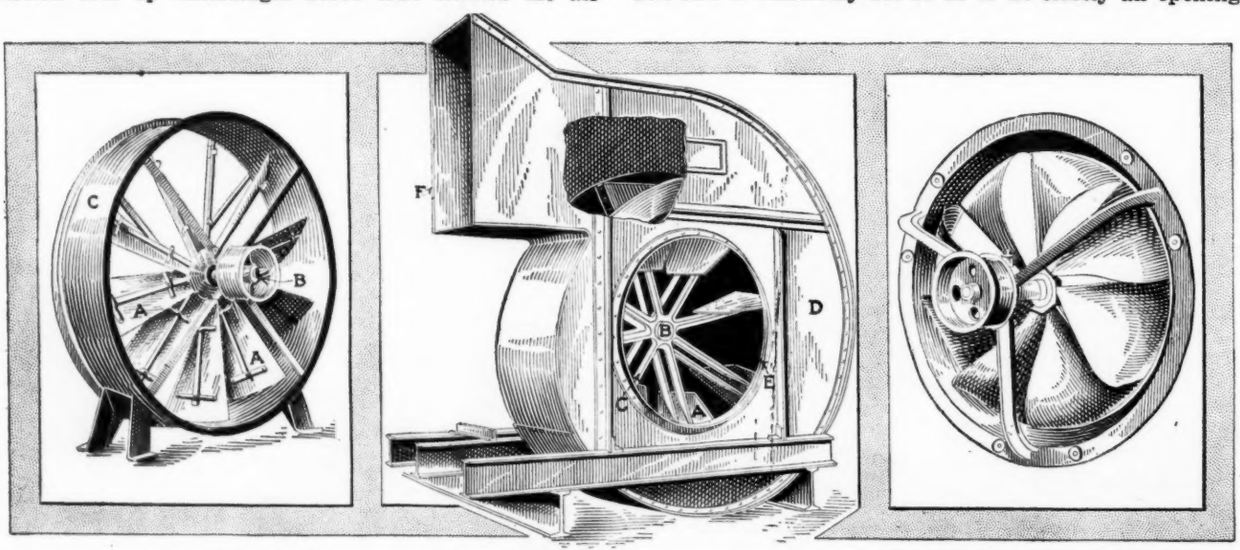


FIG. 2. DISK TYPE OF FAN FIG. 1. CENTRIFUGAL TYPE OF FAN FIG. 3. PROPELLER TYPE OF FAN

in the wall and discharges the steam, smoke or heated air directly into the outer atmosphere.

If the pressure on the outlet side of a disk fan is increased—as by discharging the air through a long pipe that offers considerable resistance to flow—the air slips back through the slow-moving center of the fan and power is used without producing any useful effect. It can be imagined that the pressure on the discharge side could be increased to such an extent that the leakage backward would equal the discharge forward and the fan would simply churn the air without producing any flow at the end of the discharge pipe.

A modification of the disk type of fan is the propeller fan shown in Fig. 3. The blades are scoop-shaped, the purpose being to handle the air without setting up reverse currents. The efficiency of the fan is thereby increased. The width and curvature of the blades at their outer ends, where their velocity is greatest, are such as to pick up the air without shock and at low pressure and move it forward, discharging it at high velocity parallel to the shaft. The propeller fan is used for the same classes of service as the disk fan.

Because of the friction of the air against the surfaces of the blades, there is a tendency for a disk fan to throw some of the air outward radially, as in the centrifugal type of fan. The desire to utilize this centrifugal effect to good advantage led to the manufacture of the cone type of fan, an example of which is shown in Fig. 4. The blades *A* are curved and are riveted to the two side plates *B* and *C*. The plate *B* is cut away at the center so as to form the inlet opening of the fan wheel. The plate *C* is solid and against it is fitted the base of the conical deflector *D* that surrounds the shaft. The edges of the blades *A* are tapered down from the edge of the inlet opening to the base of the deflector.

When the wheel is rotated, the air between the blades is thrown outward by centrifugal force and is discharged into a duct or casing surrounding the wheel circumference. The air that rushes in through the inlet opening, parallel to the shaft, strikes the cone *D* and is deflected outward, where it is caught by the blades and forced out to the discharge. The change of direction of the air is thus made smoothly, and there is little loss due to friction and reverse currents. The cone fan is used to move air under small pressure and is run at moderate speeds; that is, the outer edges of the blades are run at about 5000 ft. per minute.

The standard steel-plate fan is a centrifugal fan with straight blades, comparatively few in number, as indicated by the fan wheel shown in Fig. 5. In this case a single set of arms cast into the hub is used, but for wide wheels it is necessary to provide two sets. The blades are riveted to the side plates to obtain a strong construction. It will be observed that the side plates are not parallel, but converge toward the outer edge, thus decreasing the size of the air space between adjacent blades. The reason is that the velocity of the air increases as it moves away from the shaft and consequently the passage of a given volume can be accommodated by a smaller area of cross-section.

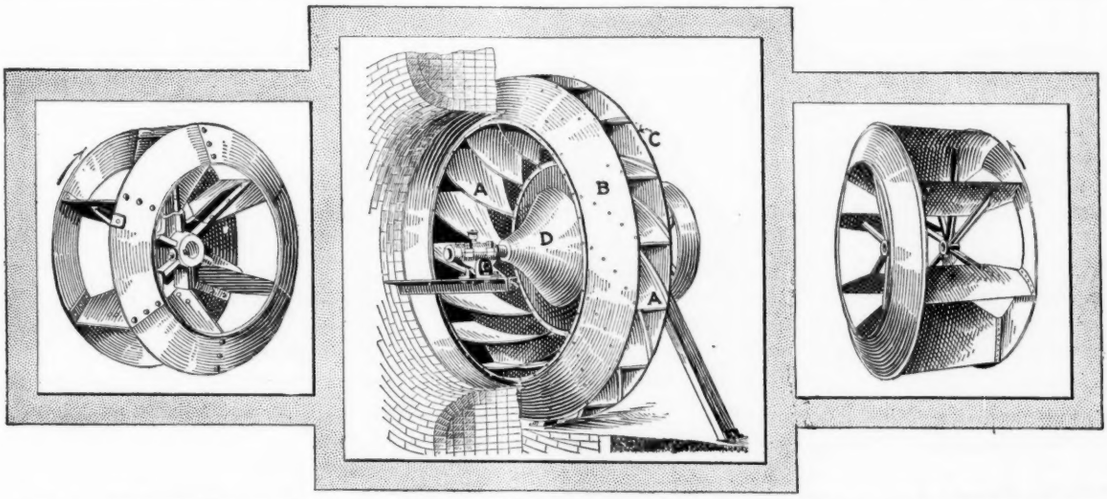


FIG. 5. FAN WHEEL WITH STRAIGHT BLADES

FIG. 4. CONE TYPE OF FAN

FIG. 6. FAN WHEEL WITH CURVED BLADES

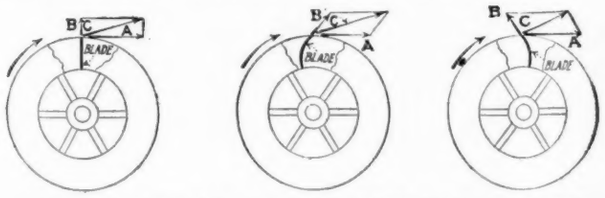


FIG. 7. EFFECT OF BLADE CURVATURE ON VELOCITY OF DISCHARGE

Steel-plate fans may be made with curved blades and the curvature may be either forward, in the direction of rotation, or backward in the opposite direction. The fan wheel of a steel-plate fan with curved blades is shown in Fig. 6. There are two hubs and sets of arms and the blades are curved backward at their outer ends.

The effect of the curvature of the blades may be illustrated by the diagrams in Fig. 7. In the first of these the blade is straight and radial, in the second it is curved forward and in the third it is curved backward. In all three sketches the linear velocity of the tips of the blades is the same, as represented by the length of the line *A*. Similarly, the line *B* represents the radial velocity of the air at the moment it leaves the blade. By completing the parallelogram of velocities and drawing the diagonal, the line *C* represents

the direction and velocity of the discharged air. In the case of straight blades and blades curved forward the resultant velocity of the air is greater than that of the blade tips, but in the case of blades curved backward it is less than the speed of the blade tips.

The next step in fan development was the production of the sirocco or multiblade type, one form of which is illustrated by the fan wheel in Fig. 8. The number of blades is very much greater than in the steel-plate fan, the depth of the blades is much less and the area of inlet opening is greatly increased. The blades are curved forward in the direction of rotation. The advantages gained by this construction are many. The inlet opening is made almost equal to the diameter of the wheel, because of the shallowness of the blades. The space between adjacent blades is small, and eddy currents are less likely to be set up. At the inner end the blade curve is approximately at right angles to the direction of motion, but at the outer end it is inclined forward at a sharp angle. As a result, the space between adjacent blades grows narrower toward the tips and the velocity of the air is increased as it flows outward. With a fan of this type the volume and velocity of air discharged at a given speed are considerably greater than for a steel-plate fan at the same speed. Noise and vibration are greatly reduced by the use of the multiblade construction. Another make of multiblade fan wheel, having but a single inlet, is shown in Fig. 9. In this case the overhung end of the wheel is braced and stiffened by four stay-rods riveted to the ring *A* and bolted into the hub *B*. The hub is made conical to deflect the incoming air outward into the blades with as little commotion as possible. This make of wheel is also built with double inlets, consisting practically of two single-inlet wheels placed back to back.

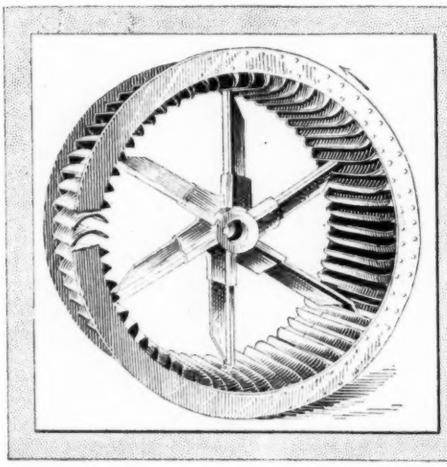


FIG. 8. MULTIBLADE TYPE OF FAN WHEEL

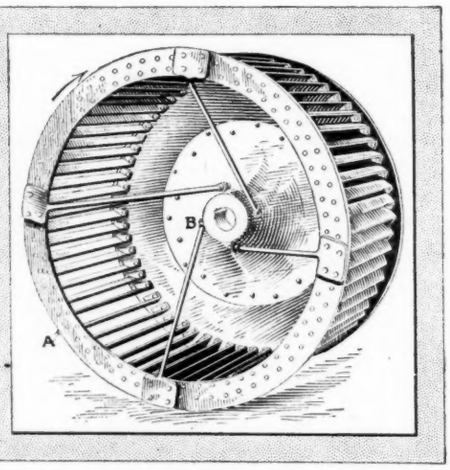


FIG. 9. SIROCCO TYPE OF FAN WHEEL

A further development of the multiblade construction is shown in Fig. 10. As in the types already illustrated, the blades are curved forward from the inner to the outer edges. In addition they are curved from side to side so as to produce a number of pockets in each blade. The object of this construction is to obtain a more uniform distribution of the air along the blade, eliminate side slip of the air along the blade due to its entrance velocity and direction and increase the velocity of discharge. The illustration shows a wheel for a fan of large size, the central annular ring serving to stiffen the wide wheel.

The conoidal fan wheel shown in Fig. 11 is simply the application of the cone principle to the multiblade type. The multiblade fan causes a rapid flow of air into the inlet opening, and there is a tendency for the rear ends of the blades to take most of the air. The conoidal fan has blades that are narrow at the front and wide at the rear and the angle of curvature is sharper at the front than at the rear, so that the work may be distributed evenly over the blade. A conical hub deflects the air outward with small loss of power or efficiency. Blowers and exhausters are centrifugal fans of practically the same internal construction. The difference between them is that the blower has two air inlets, whereas the exhauster has but one. A blower of a widely used type is shown in Fig. 12, consisting of a cast-iron casing inside which rotates a wheel much like that shown in Fig. 5. This form of blower is particularly adapted to furnishing forced draft for boilers and blowing powdered coal into furnaces, although it is used for many other purposes.

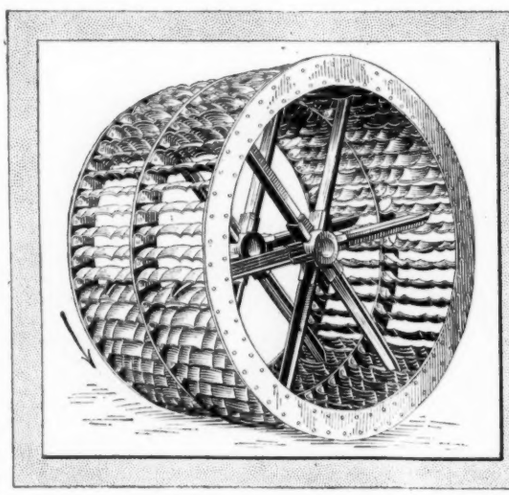


FIG. 10. LARGE WHEEL OF MULTIBLADE TYPE

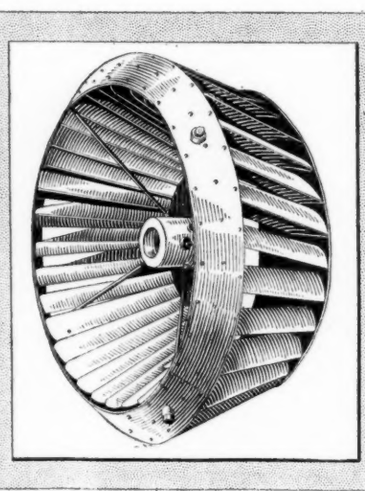


FIG. 11 FAN WHEEL OF CONOIDAL TYPE

For pressures as high as 16 oz. per square inch the style of blower shown in Fig. 13 is available. The casing is made in halves, one of which is removed to show the wheel. It is composed of a large number of narrow curved blades held between side plates and made with two inlets. The pressure of the air discharged depends on the speed of the wheel. It is designed to produce a high velocity of discharge and so deliver a small volume of air at high pressure. It will be noted that the blower in Fig. 13 bears a strong resemblance to a centrifugal pump. The principle of action is the same, in that the fluid is given a high velocity by the rapid rotation of the fan wheel or impeller and then the kinetic energy of the swiftly moving stream is converted into pressure by reducing the velocity. This change of velocity into pressure is accomplished by the spiral casing into which the air is discharged.

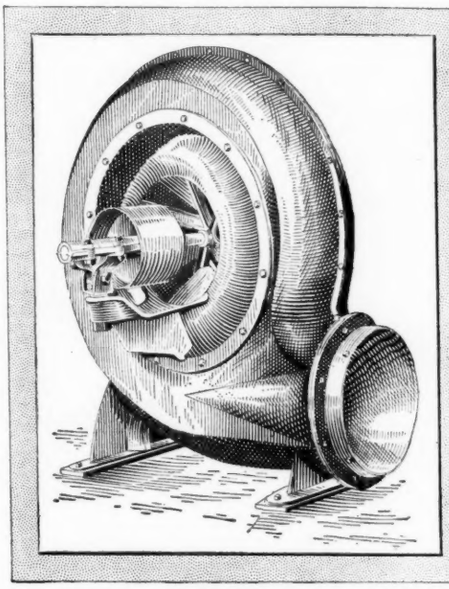


FIG. 12. EXTERIOR OF A COMMON TYPE OF BLOWER

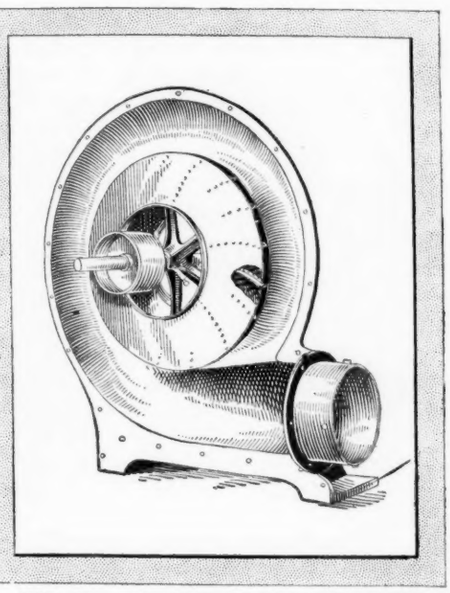


FIG. 13. SECTION OF HIGH-PRESSURE BLOWER

What is known ordinarily as a positive blower is shown in section in Fig. 14. It consists of a pair of two-lobed impellers *A* and *B* that run together inside a casing *C*. The shafts to which the impellers are keyed are forced to turn at the same speed by being connected by a pair of gears of the same size on the outside of the casing. Air enters at *D*, is caught between the impeller and the casing as at *E* and is carried around and discharged at *F*. As the impellers are in contact with each other and with the walls of the casing, there is no chance for the air to return and a definite volume is delivered at each revolution. This type of blower is used for furnishing air blast to forges and cupolas.

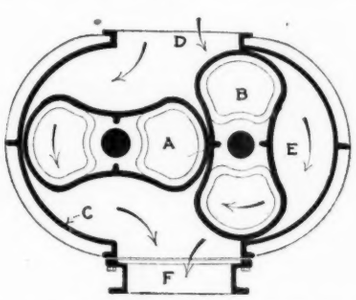


FIG. 14. DIAGRAM OF POSITIVE BLOWER

If the steel-plate casing incloses the entire spiral passage around the fan wheel, as in the fan shown in Fig. 1, it is called a full-housed fan. In many cases, however, a part of the passage is formed in the foundation on which the fan is placed, and the fan is then said to be three-quarters or seven-eighths housed, depending on how deeply it is set. In Fig. 15 the fan at the left is three-fourths housed and the other is seven-eighths housed.

The discharge of a fan is designated as top or bottom horizontal, top or bottom vertical, etc. For example, Fig. 1 shows a right-hand top horizontal discharge, while Fig. 15 shows at the left a left-hand top vertical discharge and at the right a left-hand top horizontal discharge. The hand of a fan is determined by standing so as to face the driving pulley and noting on which side of the shaft the fan outlet lies. The capacity of a fan—that is, the number of cubic feet of air per minute that it will discharge—depends on the speed of the fan and the pressure against which it works. Obviously, these conditions are different for different applications, and for that reason it is not feasible to show either a table or a formula that will give the capacity of a fan under any and all conditions of service.

Every fan manufacturer publishes tables of capacities of his different styles of fans at various speeds and pressures and these should be used when information as to capacity is desired. In some cases the tables may not allow for internal friction or resistance due to pipes and ducts. It is well, therefore, to determine first of all the basis on which the table is computed. If the resistances are not taken into account, the stated capacity will be larger than can be obtained in practice. Similar tables are published as to the horsepower required to drive fans. Here again it is best to rely on the data given by the manufacturer, as they include the results of wide experience in the use of fans.

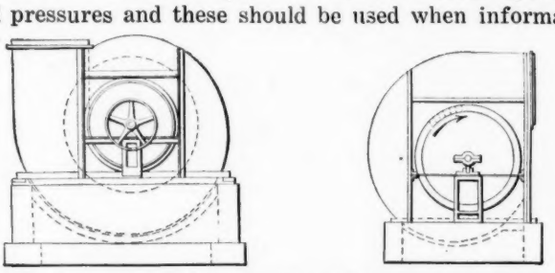


FIG. 15. THREE-QUARTERS AND SEVEN-EIGHTHS HOUSED FANS

Care of Heating and Ventilating Equipment—VII

By HAROLD L. ALT

This article is a discussion of the two-pipe system of heating, giving pointers on the things to guard against to avoid trouble and how to correct certain defects when found to exist.

TWO-PIPE gravity steam systems utilize the same types of steam and air valves as one-pipe systems, and like the one-pipe system the piping may be arranged for up-feed (Fig. 1) or down-feed (Fig. 2) and either may have the air valve discharged into the room or connected to an air-line system either with or without an air-line pump as previously described. The down-feed, or "Mills system," allows the use of slightly smaller risers or, rather, drops, and since the condensation flows in the same direction as the steam, the danger of water-hammer and noise is greatly reduced. The two-pipe system is distinguished from the one-pipe by the radiators having a separate return connection which allows the condensation to flow down a different riser from that from which the steam is fed to the radiator, but the horizontal main piping, header or loop, may be almost identical with that used for a one-pipe system.

The standard tappings for two-pipe gravity steam radiators are as follows:

Radiator Surface	Supply Pipe	Return Pipe
Up to 48 sq.ft.	1 -in.	¾-in.
48 to 96 sq.ft.	1¼-in.	1 -in.
Over 96 sq.ft.	1½-in.	1¼-in.

If the runout from the riser to the radiator is long, it is generally made one size larger up to the radiator

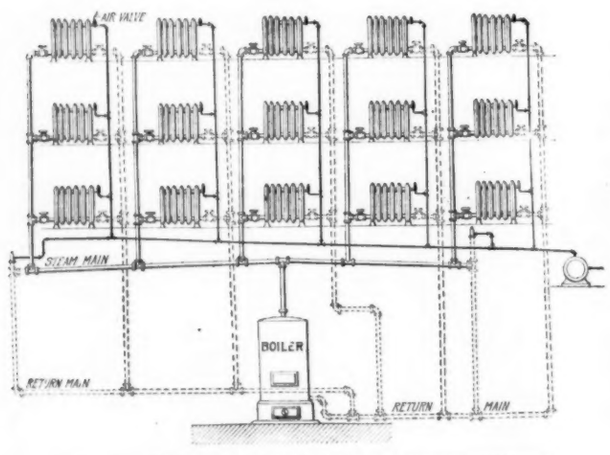


FIG. 1. TYPICAL TWO-PIPE UP-FEED SYSTEM

valve. To operate in a quiet and satisfactory manner the horizontal piping must be large enough to supply the maximum amount of steam and must be properly pitched and dripped so that no water can accumulate in it, otherwise there will be objectionable noise. As a general thing but little trouble is encountered on account of the pipe not being big enough to deliver the required amount of steam, because the average demand is small and the maximum load in a heating system is carried only for a few days out of the entire heating season. While it is entirely feasible in heating work to run the drip in both the main header and riser against the flow of the steam, owing to the low velocities used, it is always better to arrange for the drip or condensation to flow with the steam instead of against it; therefore such piping is recommended as being theoretically correct and smaller pipes may be used, giving greater economy. As a rule the steam main rises from the boiler to a high point and then slopes downward from this point to the end of the line or point of drainage of the loop. This does not

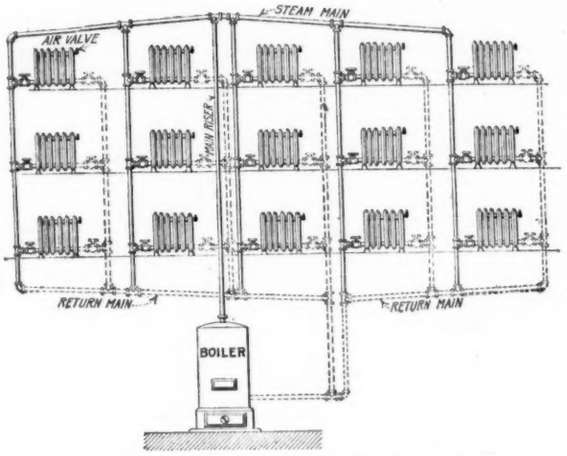


FIG. 2. DOWN-FEED TWO-PIPE JOB

mean that there cannot be a further rise at any point where it may be desirable, but a drip must be provided, as illustrated in Fig. 3, at the point of rising.

"Wet" returns are always preferable, and if it is impossible to carry them below the boiler-water line, a false water line may generally be used. In many systems not operating properly, the trouble may be traced directly to the dry return or air binding or both.

Piping systems, on the supply steam side, may be divided into steam mains carrying all condensation or those carrying no condensation except their own and that for short distances while the return lines are either "wet" or "dry." Drips, bleeders or air lines do not materially affect these classifications.

The most common system of steam piping on small jobs—which at the same time utilize one-pipe radiators—is that known as the circuit or loop system. A typical layout of such piping is shown in Fig. 4, and it will be noticed that the main rises up directly from the top of the boiler to its high point, slopes steadily down from there until it completes its circuit, dropping below the water line near the boiler. If it is necessary to raise the main at any point, it may be done as shown in Fig. 3. With such a main there is practically no return pipe and one-pipe radiators are almost invariably used, the one-pipe risers being branched from the main as illustrated in detail at *A*, Fig. 5, using a tee turned to 45-deg. and a 45-deg. elbow. This results in the steam entering the branch without conflict with the condensation returning in the lower portion of the branch, but if the branch is taken from the main

vertically, as at *B*, then the steam flowing in the main must force its way through a spray of water at each branch, interfering with the flow and causing more or less drop in pressure.

Probably the most frequent cause of trouble in such a piping system is the neglect to provide properly for air relief, for some steamfitters are not as familiar with the essential points on air relief as might reasonably be expected. Of course, air relief in the radiators is secured through the radiator air valve, but air may also be contained in steam piping, especially large mains, so that when the main cannot easily be relieved through the radiator connections, separate air venting must be installed. If no air valve is placed at the point where the main drops below the water line, the operating engineer is likely to experience trouble every time the system is started up, because air gets trapped in the main between the water and steam, thus interfering with the returns and circulation. Placing an air

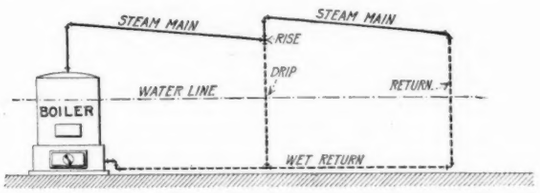


FIG. 3

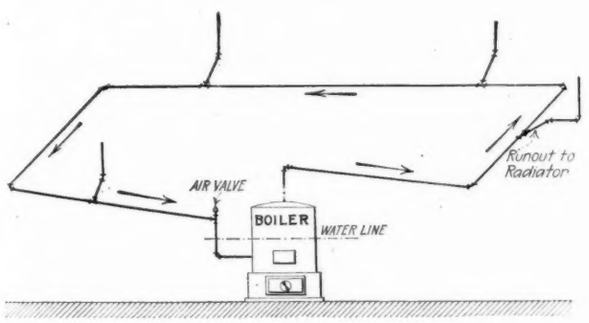


FIG. 4

TWO BASEMENT STEAM-HEATING MAINS

Fig. 3—For low headroom. Fig. 4—Used where headroom is ample for one-way drainage.

valve at such a point will relieve the air, but may result in trouble from water leakage due to the cooler water of the return spouting through the open valve. This can usually be remedied by locating the air valve 12 to 18 in. above the header, as shown in Fig. 6, so that the air and water will separate before reaching the air valve; but if the steam main is too small, the water may back up into the valve from the boiler, especially when the level of the low point of the steam main is near the water line of the boiler; for when the distance between the boiler water line and the low point of the steam main is small, a very small loss of pressure in the steam main will result in the water of the boiler backing up to the air valve and flooding it. Usually, 30 in. is considered the minimum allowable distance between the boiler water line and the lowest point of the steam main, which corresponds to about one pound drop in pressure in the line.

It is interesting to note the rise of the return water in a wet return due entirely to drop in pressure, as shown in Fig. 7, where the return stands higher in each return connection as the location becomes more and more remote from the boiler. Near the boiler where the drop is small, the return rises but little above the boiler-water line, but at the end of the system, with one pound loss in pressure, the return will rise

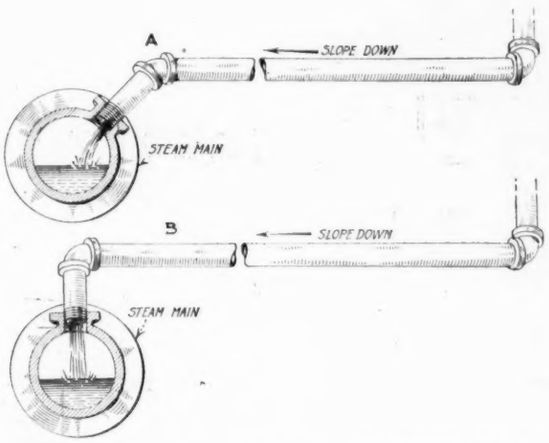


FIG. 5. RISER BRANCHES FROM STEAM MAIN

about 2.3 ft. and the various other levels will be approximately as illustrated.

The formula for checking the size of a steam main carrying radiator condensation has already been stated as $D = \frac{1}{6}\sqrt{R}$, where D is the diameter of the pipe in inches and R is the number of square feet of equivalent direct radiation.

When the return drops below the water line at the end of the main, it is usually reduced one pipe size. A second arrangement of piping resembles the circuit main described, but is used for larger systems. This may be termed the "split circuit" arrangement. Usually, if the drop below the water line is made near the boiler, as shown in Fig. 8, the system is spoken of as a split circuit, while if the drop is made at a considerable distance from the boiler, as shown in Fig. 9, it is termed a "wet return" system. Such piping is equally suitable for either one-pipe or two-pipe systems, the one-pipe branches being connected to the steam main as illustrated in Fig. 5, and the two-pipe supply and return branches being connected as illustrated in Fig. 9. Where the two-pipe arrangement is used, the formula for pipe size becomes $D = \frac{1}{10}\sqrt{R}$ instead of $D = \frac{1}{6}\sqrt{R}$, as given for a one-pipe job, thus reducing the diameter of the steam main slightly. The size of

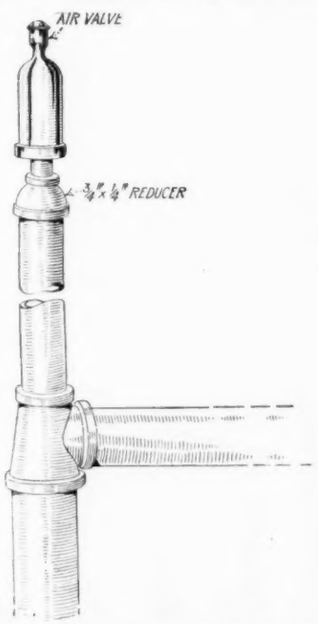


FIG. 6. AIR VENT ON MAIN

the wet return may safely be based on the following schedule:

Sq.Ft. of Equivalent Direct Radiation	Pipe Size
3,000	1¼-in.
6,000	1½-in.
12,000	2 -in.
20,000	2½-in.
36,000	3 -in.
60,000	3½-in.
80,000	4 -in.

It is customary, however, to make a wet return one or two sizes larger than given in the foregoing table

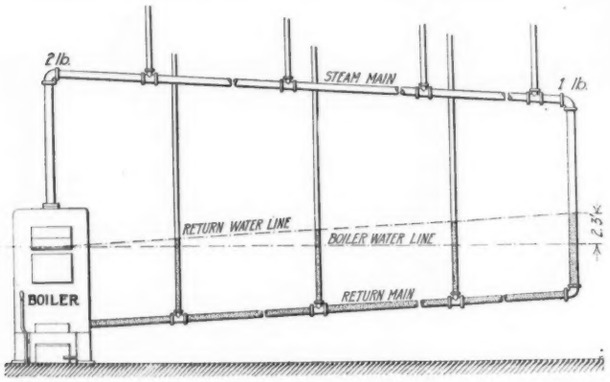


FIG. 7. STEAM PRESSURE DROP PERMITS WATER TO RISE

in order to allow for partial stoppage by sediment, scale, etc., collecting in this low part of the system. A rough rule is to make the return one-half the diameter of the supply pipe serving the radiation.

Difficulty is sometimes encountered with a two-pipe system where one riser or return serves two radiators

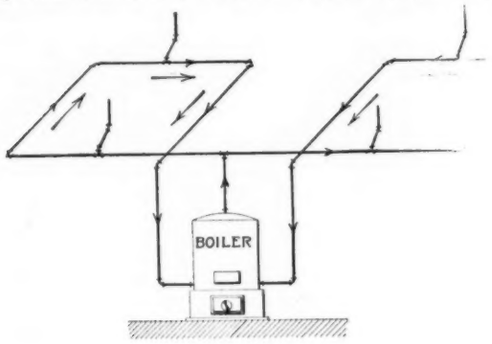


FIG. 8

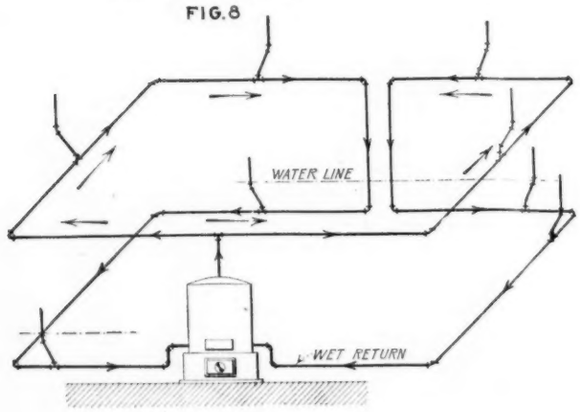


FIG. 9

STEAM MAINS FOR LARGE INSTALLATIONS

Fig. 8—Known as a split circuit. Fig. 9—A wet return.

located directly opposite to each other, one much larger than the other. The larger radiator will sometimes heat only at the ends and will remain cold in the middle part. A typical instance of this kind is illustrated in Fig. 10, where two radiators are supplied by separate risers but both have their returns connected to a common return. When steam is turned into the system (if the bottom of the return riser is water-sealed, as it should be), the steam will enter both radiators at the supply end and will start pushing the air out through the air valves; but because both air valves discharge at the same rate and one radiator is two or three times as large as the other, it follows that the small radiator will be rid of air long before the large one, and the steam then proceeds out through the return connection of the smaller radiator and across

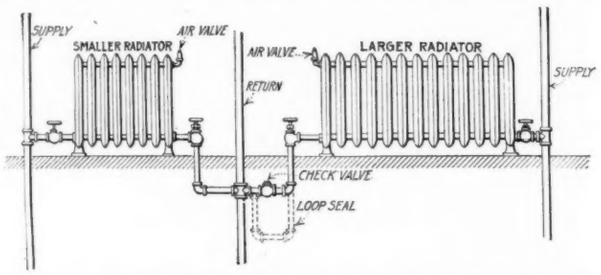


FIG. 10. RADIATOR CONNECTIONS THAT SOMETIMES CAUSE TROUBLE

through the return connection into the larger radiator at the air-valve end. As soon as the steam comes in contact with the air valve on the large radiator, it shuts off, imprisoning the remaining air in the larger radiator. The best remedy for such trouble is to put in a check valve or a water seal in the return from the large radiator, as shown.

A common arrangement of steam and return mains is that known as the "dry return" system, illustrated in Fig. 11. It is used almost exclusively for two-pipe systems of heating. This dry return system usually causes the operating engineer a lot of trouble, and its use is warranted only where any other is impossible,

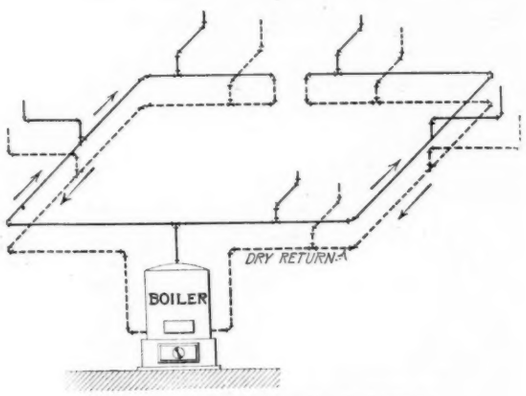


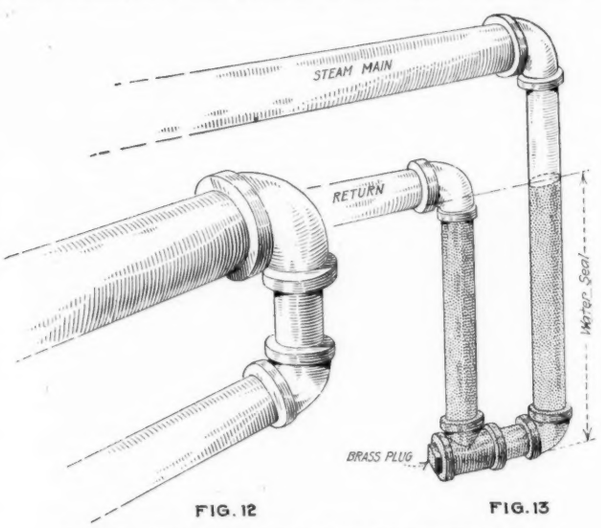
FIG. 11. DRY RETURN SYSTEM

but if properly installed it can be made to operate satisfactorily as most of the trouble is due to incorrect methods of piping. Trouble can be avoided by having all connections between the steam main and return water-sealed. The depth of seal required depends on the maximum difference in pressure between the supply and return mains as explained in connection with the rise of water in the return pipe, excepting that in this case the rise occurs in the water seals. Drip connections should never be, but often are, made as shown

in Fig. 12, as trouble is almost sure to result. These connections should always be sealed by loops, as shown in Fig. 13, or by establishing a false water line in the system. Sealing every connection to a dry return line makes it, as far as operation goes, equal to the wet return. The overhead return may be water-sealed by connecting an "inverted seal" forming a trap of whatever depth of seal is required. This is accomplished by a rise in the line before dropping down to the lower level, as shown in Fig. 14, this rise being connected to the steam line by a balance pipe in order to prevent siphoning.

There is more than one way to operate a gravity steam plant of either the one-pipe or two-pipe design. Many smaller systems are controlled entirely from the boiler room by supplying steam for shorter or longer periods during the day as the severity of the weather demands. For instance, during a period when the outside temperature is around 35 deg. F. steam might be supplied for alternate hours, while with 20-deg. weather it would probably be necessary to keep steam on for two hours and off for one hour, or approximately 67 per cent. of the time on. With zero weather steam would be carried on the system all day, but when the weather moderated again, the "off" periods could be made longer or more frequent to about 60 deg. outside temperature, when there would be little need of artificial heat.

This method, if properly carried out, is one of the most economical ways of running a small plant, as it insures against a waste of heat in unoccupied rooms where radiators—left turned on through carelessness—



RIGHT AND WRONG WAY TO DRAIN HEADERS
Fig. 12—The wrong way. Fig. 13—The right way.

would cause overheating and waste of coal. The best way to determine the amount of heat required is to select some room of reasonable exposure and easily accessible to the operating engineer at all times. A little experimenting will soon show what temperature this room will heat to by the time all the other rooms have reached 70 deg. F. With this room as a guide, it is comparatively easy—by maintaining the required temperature there as shown by experiment—to maintain a very comfortable temperature throughout all parts of the building.

Of course if the radiation is not evenly distributed, the results of trying to operate in this manner will be that some rooms, carrying too much surface, will be overheated while others, with less surface, will be too slow to warm up. The only remedy for this is to readjust the radiator surface until each room has its proportional amount.

Another method is to carry steam pressure at all times, depending upon the occupants to control the radiators so as to maintain desirable temperatures

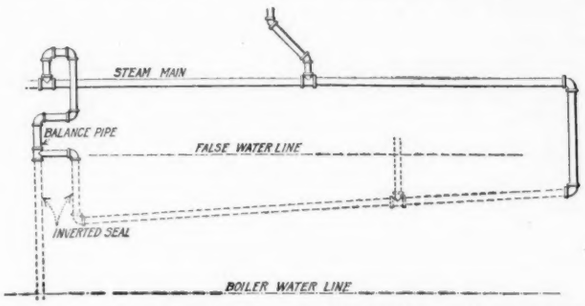


FIG. 14. INVERTED SEAL FORMS FALSE WATER LINE

throughout. This method is not usually successful, being subject to abuse by many persons who would always open a window when too warm instead of closing off the supply of heat. If temperature-control apparatus is installed, however, the second method must be used in order to have steam always available when the valves open.

One suggestion that may help to conserve the coal supply where it is necessary to keep on steam constantly is to place diaphragm valves in any lines that can be shut off for certain periods. In dormitories the heat can be cut off from 12 o'clock midnight to 5 or 6 in the morning without inconvenience and be more healthful for all concerned. In schools the gymnasium, auditorium and other departments in use only a portion of the day are easily shut off at the proper time without affecting the rest of the building.

Canadian Central Stations

The Dominion Bureau of Statistics in coöperation with other departments, has completed a census and directory of the central electric power stations in Canada, including only stations developing electric power for sale.

The capital invested in power stations reaches a total of $356,004,168, of which 79.5 per cent. is invested in commercial stations, and 20.5 per cent. in municipal or publicly owned stations. The total revenue derived from the sale of electrical energy is $44,536,848, of which $29,135,399 was secured by commercial and $15,401,449 by municipal plants. The primary power installation in central stations totals 1,845,161 hp., of which 1,652,661 hp. is derived from water, 180,800 hp. from steam and 11,700 from gas and oil. The actual cost of construction of hydro-electric power stations per installed horsepower (omitting real estate, transmission and distribution equipment) for 70 representative stations throughout Canada with an aggregate turbine installation of 745,797 hp. was $50,740,458, being an average cost of $68.03 per installed turbine horsepower.

Elliott-Ehrhart Jet Condenser

The rapid development of turbine machinery has been paralleled by a like development in condenser apparatus. In fact the turbine, in a large measure, owes its economic position to the high-vacuum condenser. Without the condensing apparatus to maintain the high vacuum requirements, the turbine would not be able to maintain its position.

The condenser as it was known ten or fifteen years ago was not at all suitable for maintaining the high vacuum required by modern turbines, so that the condenser of necessity evolved to its present-day form. The development of condensers has been based on systems that differ materially in their original form, but which have gradually grown toward comparative similarity. Each particular school of design has something to recommend it.

It is a natural development that the designer of a new line of condenser products makes an effort to incorporate in his apparatus those elements which the collective experience of operator, builder and designer have found desirable. This has been done in the instance of the Elliott-Ehrhart jet condenser, manufactured by the Elliott Co., Pittsburgh, Penn., and shown in Fig. 1. It is of the vertical type. Steam enters at the top and the condensing water and products of condensation are pumped out by a centrifugal pump at the bottom of the apparatus (see Figs. 2 and 3). The mixture of steam and water is accomplished by the use of spray nozzles so designed as to break the water into small enough particles to insure a mixture of steam and water without presenting undue resistance to the flow of water. The nozzles are liberal in area, so that ordinary débris in the circulating water will not choke them. The spray nozzles placed in the condenser head are of the helical type, formed by having a twisted division wall located on the inside of the cylindrical nozzles (see Figs. 2 and 3).

The water in passing through the nozzle is given a rotary motion about the axis of the nozzle so that it is torn into very small particles by the centrifugal force of rotation. This design of nozzle has been found to give just the proper amount of centrifugal rotation to the water, tearing it into fine particles.

The openings in the head for inspection and the removal of material that has passed the intake screens, are arranged so that the removal of one nut will give access to the interior. This is accomplished by attaching the cover plate by means of a crab. These openings are placed on the lower surface of the overhanging condenser head, so that the turbine foundations can be bolted close to it. No ground joints are used. Ordinary commercial gasket is the packing, which insures a tight joint when the handhole cover is in place. The centrifugal pump for handling the condensate forms the base of the condenser and has the pump casing split vertically and parallel to its axis, so that the removal of the cover permits the taking out of the shaft in the same manner as with the ordinary horizontally split casing of the centrifugal pump.

The use of the steam ejector for removing air from the condenser system makes the apparatus one of extreme simplicity and efficiency, when it is realized that the exhaust from the ejector may be used for feedwater heating, and thus the maximum B.t.u. are utilized.

Owing to the restrictions of war times the jet condenser has been the first to appear on the market, although surface condensing units are included in the product of the company.

In Texas there is an area having a length of 500 miles and a width of from 50 to 100 miles under which is a bed of lignite estimated to contain about 30 billion tons. This is said to be the largest known deposit of lignite in the United States.

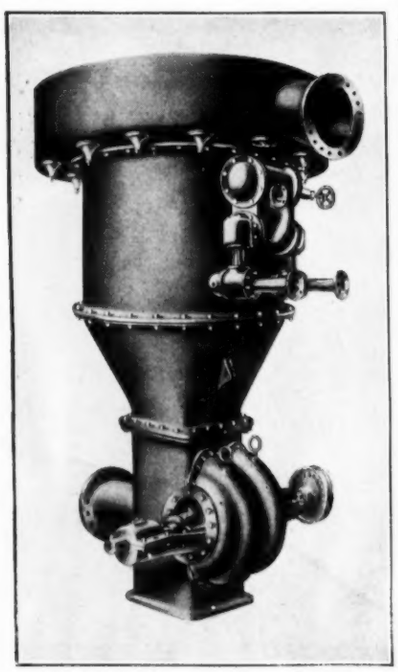


FIG. 1. EXTERIOR OF CONDENSER

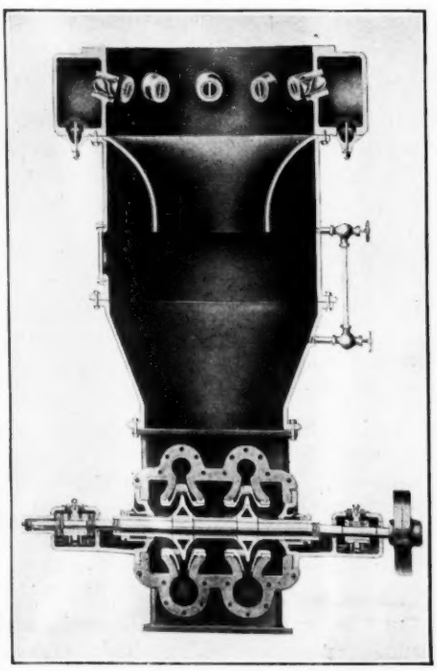


FIG. 2. SECTION THROUGH CONDENSER

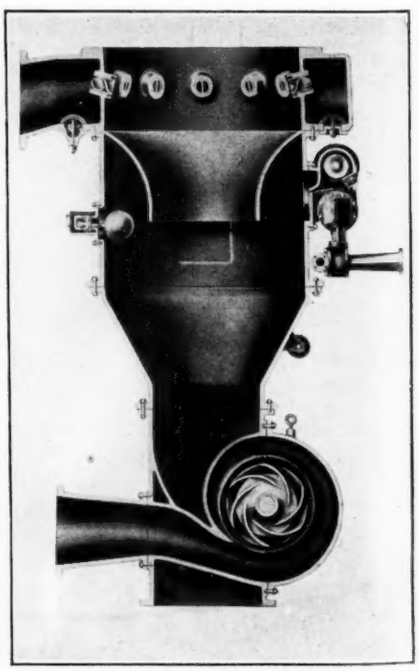
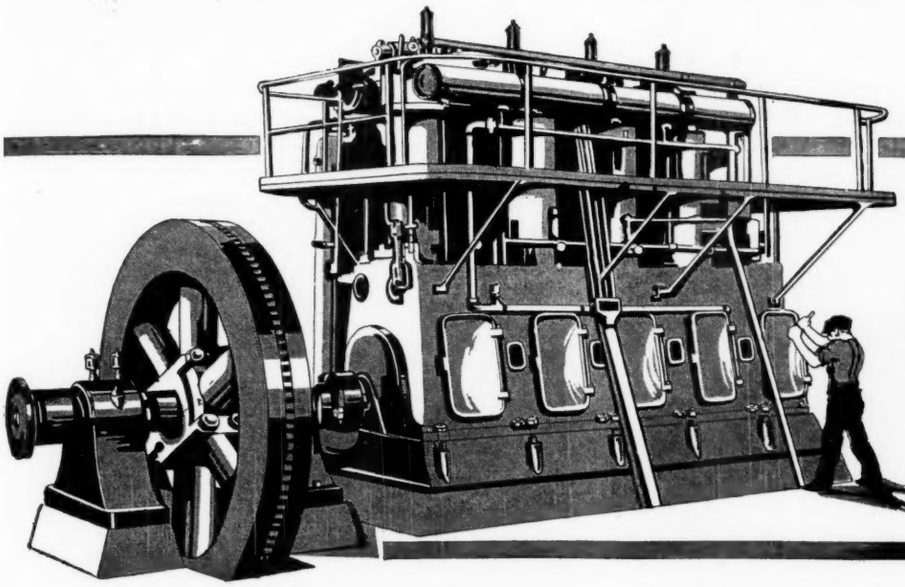


FIG. 3. SIDE SECTIONAL VIEW



Talks on DIESEL Engines

by L. H. Morrison

V—At this meeting the discussion turns to the relative advantages of A frames and box frames, with side remarks on cooling hot bearings.

AT THE following meeting of the class, Egan announced that he intended to take up the discussion of piston and cylinder details, but Woods interposed an objection.

"Before you do that, I wish you'd talk about engine frames," he said. "Last evening I had an argument with Kelly. He says the A frame is lots better than the box frame, and I don't think it is." The young fellow tugged belligerently at a lock of hair that hung over his forehead.

The chief joined in the laugh that followed this declaration of war.

"I can understand Kelly's point of view, and if the old splash system was still used I'd agree with him. But let's hear Kelly's side of the question. I have pictures of both types of frames, built by the same company"—here J. R. displayed the illustrations shown in Figs. 1 and 2—"and so the question of make will not enter into the argument." He turned to Kelly. "What's your objection to the one-piece frame, or box frame?"

"Well," began Kelly, who dearly loved an argument, "the kick I have against the box frame is that it's a box. A fellow's got to crawl through the door if he wants to do any work, and in the crawling he ruins a perfectly good suit of overalls and a sweet and loving disposition. When he does get in, can he do anything? I should say not! He spends all his time wiping the oil out of his hair or off the seat of his pants. Another thing, when the doors are closed, you can't tell where a knock comes from. If it's in a middle crank it always sounds as if it was the end cylinder. If your crank box or main bearing runs hot you never know about it until the engine is about ruined.

"On the other hand, look at the A frame on our 500-hp. engine. Look how easy it is to take out the light sheet-steel covers from between the frames, and then the whole insides is right there. Are you worried if your bearings are warm? Then raise up the cover or slide the little door and put your hand right on the hot place. Do you get your hair full of oil? If you have to take out a crank bearing, it's easy to slide it out between the frames. Me for the A frame!"

"But," said Woods, "Kelly is still talking about a box frame with splash lubrication. From what I've seen of this sort of system, I wouldn't have it on a bet. But at the beginning it was understood that the splash outfit was ruled out. Take the two photos the chief has here. The box frame isn't supplied with a splash, but the bearings have a flood or continuous system of oiling. I'll agree that even with this stream lubrication some oil will be thrown off by the crank, and if the doors are opened while the engine is running somebody will get oiled. But the inspection ports on the box frame are just as serviceable as they are on an A frame. In neither frame can you touch the main bearings by reaching through the handholes or ports. As for getting at the crank brasses or main bearings to remove them—the box frame is much handier. The box is roomier and a man can get inside and have space to lift the brasses. Last Saturday night I helped to take out the No. 2 crank brasses on the A-frame engine, and it was a job. There isn't enough room to raise your back when you start to lift the box, and after you get hold of the box you've got to turn sideways to get it out between the legs of the frame. Now, Mr. Egan, let's hear your views."

The chief paused thoughtfully for a moment before replying:

"I must agree in the main with Woods," he said. "As I stated before, if we must use a splash system, I'm against the box frame. However, this is not necessary, and all builders of box frames have abandoned the splash.

"In oil engines, as in steam engines, the tendency is to adopt accepted ideas of design. If the Diesel engine

At the next meeting piston rings and piston construction will be discussed. Egan will explain to the class the reason for the scoring of cylinders and the sticking of pistons

had originated in America, undoubtedly it would have been built horizontally. You can't deny that horizontal engines are easier to adjust, for all parts are within reach of the floor. Pistons are easier to pull, shafts easier to adjust, and so on. So I say that if the original design had been American, it would have been horizontal, since the American engineer was familiar with horizontal engines. Practically all American firms who

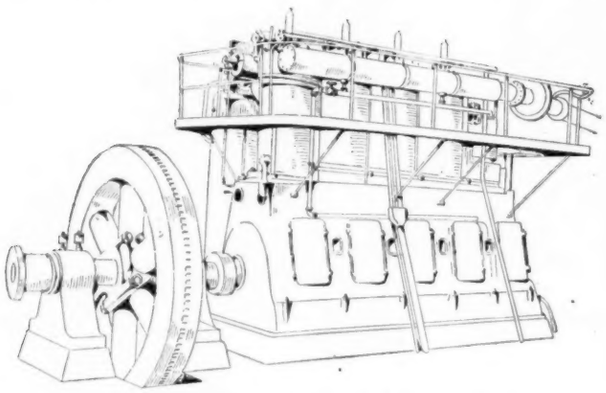


FIG. 1. ENGINE WITH A BOX FRAME

have gone into the Diesel game during the past few years, with an American design, have adopted the horizontal frame.

"On the other hand, the European practice was to build vertical steam engines. I presume that the cost of raw materials prompted this since a vertical engine can weigh considerably less than a horizontal. It may have been their desire to produce a longer-lived machine, also a better-balanced one. With these facts in mind, it's easy to understand why the Diesel engine, when first produced, was vertical and why this design still predominates.

"The same reasoning applies to the box and A frame. The A frame can be made lighter in weight than the box, thus reducing the raw-material cost. Against this, the A frame involves more labor cost, but this is cheap in European countries. In designs built under European plans in this country we should not wonder that the A frame predominates. It's noteworthy, however, that the drift of even these builders of the A type is toward the box frame.

"From the viewpoint of operation the box-frame engine is easier to keep in shape. You notice that the A frame on our 500-hp. engine has a tendency to give slightly at the junction of the A flanges and the base. I don't suppose this amounts to more than half a thousandth of an inch, but figure what this means as regards the movement at the cylinder. The base flange is about 18 in. in length. If there is a thousandth of an inch vertical movement at one end with the other edge of the flange as a fulcrum, and the cylinder top is 14 ft. from this flange, the horizontal displacement will be around a hundredth of an inch. This movement occurs to the piston as well. It's easy to see that the brasses will wear out of true—the ends wearing cone-shaped. This may be theory, but I do know our A-frame engine demands more crank adjustment than does our new box-frame engine. As Woods states, the box frame is easier to work in; and if I were buying an engine, I'd insist that the manufacturer put ports in the frame between the doors, so the engineer could see if the bearings were running warm. But I would see that the operator kept these inspection ports closed. I have noticed that some of you boys are in the habit of removing the sheet-steel covers between the A frames and running the engine open. Now, this may help to cool a warm bearing, but the best course is to pay strict attention to your oiling system and so avoid hot boxes. The breathing action of the moving piston sucks air into the frame, carrying with it any dust or grit that may be flying round. To let this grit settle in the engine frame won't help your bearings any. So remember—keep the steel guards on the engine.

"This brings to mind something I saw at the Paducah plant when I visited there last week. A hot bearing had developed on their A-frame engine and some genius had hit on the idea of running a hose line into the oil hole on the bearing cap and was allowing a nice stream of water, as well as oil, to play on the hot shaft. Any engineer ought to know that water used this way will absolutely prevent any oil getting to the shaft, and water itself is a poor lubricant. The water removed some of the heat but produced just as much by its poor lubricating qualities. I suggested to the new chief that he cut out the water and use a heavy stream of oil. When I returned from lunch I found they had discovered a new heat remover. They were then using an air hose from their air compressor and blowing the air on the cast-iron bearing housing. The bad feature of this was that the cooling was occurring from the outside, and if the housing did cool off, it would force the babbitt to grip the hot shaft or squeeze out at the ends. So my advice in case of hot bearings is to avoid water, air or anything except a generous supply of cool oil. Then, when the bearing cools off and the engine can be stopped, inspect the bearings and scrape them if they are in bad shape.

"Going back to the frame question, I believe there

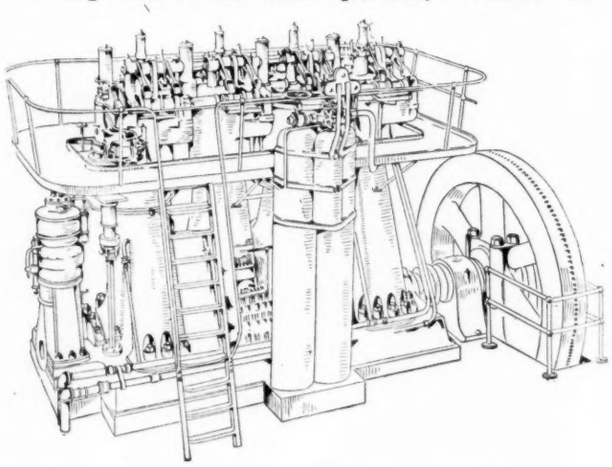


FIG. 2. ENGINE WITH AN A FRAME

are only two things that I need mention in regard to operation. One of these is—see that your bolts are always snug. The second and vital one is—keep the frame clean and free from oil leaks and settling dust."

"Chief, since you've mentioned the horizontal engine, I'd like to know which type of horizontal frame you think best from the operator's viewpoint," said Woods.

"There isn't much choice, Woods," Egan replied.

"You'll find practically all builders use a one-piece frame, as in Fig. 3, with the cylinder water-jacket cast in one piece with the frame and using a center-crank shaft. This makes a rigid construction and simplifies the manufacture. It also eliminates any danger of broken bolts between cylinder flange and engine frame.

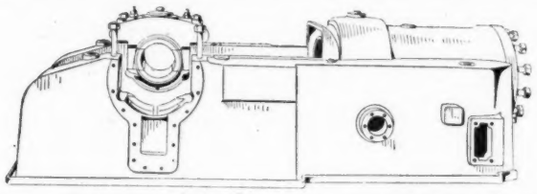


FIG. 3. ONE-PIECE FRAME FOR A HORIZONTAL ENGINE

"Fig. 3 is a fairly representative type of horizontal frame, this design being followed by practically all builders, except as to minor details. The chief feature of this type is its heavy weight. The majority of builders still adhere to the trunk piston. A few make use of the crosshead type, and consequently this latter engine has a frame considerably longer than the former.

"In operation the horizontal frame allows the engineer to have easy access to all parts, and it is easier to dismantle and adjust. In sizes up to 300 hp. I think it ideal. Going to larger sizes, we find all builders using the twin engine design, having the flywheel and generator between the two frames. In this case the unit is made up of two distinct engines. Frequently each engine has its separate governing mechanism. In operating such a unit on a lighting circuit, there is likely to be trouble with flickering of the lights. It seems practically impossible to make the action of the two units synchronize.

"If the load demands an engine capacity above 200 hp. and the horizontal type is decided upon, by all means insist on two separate engine-generator units."

"I can't get your argument, J. R.," Woods said. "Why will this help matters if the engines don't synchronize?"

"But you've forgotten the fact that we are now figuring on two generators. If the generators are equipped with damping windings, the tendency to fall out of step is practically destroyed.

"Another important item to consider is the available room space. The horizontal units in large sizes demand much greater floor space than the vertical engine, and ordinarily floor space is of more moment than headroom, unless the outfit is installed in a basement."

Conditions in the Power Industry

By L. W. ALWYN-SCHMIDT

A digest of the reports of United States consuls on the power situation in various parts of the world and the influence of the war upon this important industry. Also see "Power," Dec. 3, 1918.

POWER conservation is still agitating the minds of English engineers and the coal controller has appointed four hundred experts to consult with and advise power users with a view to reducing the waste of power and coal. The Coal Control Technical Committee believes that there is in England a tremendous waste of coal and that it can be eliminated; but to change the situation will take several years. The advisory work, therefore, will be continued during peace until the installation of more efficient power plants is guaranteed. The English government seems to be of the opinion that unskilled handling of the power plants—especially the employment of many unskilled stokers—has a good deal to do with the wasteful habits complained of. More than 45,000 firms will be examined, only 364 of which so far have been visited, and it is estimated that a saving of 106,000 tons of coal will result from this work alone.

To make possible a more effective control of the consumption end of the coal-conservation scheme in England, it became necessary some time ago for the coal controller to take the leading gas works under his jurisdiction. So the Bristol Gas Co. was operated under the administration of the controller. It appears that the gas works had to assume a good deal of the load generally carried by the electrical power plant in Bristol, by supplying a larger share of the lighting facilities. The electrical plant was compelled to increase its supply facilities considerably so as to be able to deliver enough power to local industries. It is interesting to note that more than 80 per cent. of all the electrical energy produced by the municipal power plant in Bristol was taken up by industrial enterprises.

Following the precedent of other cities, Glasgow has been compelled to add to its local power supply. The general plan for this extension was made before the war and work had been started in 1914, but it was suspended at the outbreak of the war. The unexpected increase in the demand for power later made it advisable to resume construction, which was done in 1916. The site of the new station is at Dalmarnock, Scotland, and covers 45 acres on the right bank of the River Clyde. Four 25,000-hp. turbo-alternators will be installed, together with eight boilers. There will be a complete plant for handling the coal, for which there is a storage system having a capacity of 60,000 tons.

England also has given much attention to the question of providing power in India. Attempts are being made to store the waters of the monsoon and use them for hydro-electric power development. There are large parts of India which have a rainfall for three months, and during the remainder of the year the rivers dry up or run so low that no effective use can be made of them for power development. It is now contemplated to use convenient valleys to form reservoirs. The Tata hydro-electric scheme is of this character. It is expected that by erecting a series of dams enough water can be provided for creating 100,000 horsepower (C. R. 231).[1]

[1] C. R. indicates "Commerce Reports" of 1918.

The increasing supply of energy at cheap rates to the cities and villages of Switzerland has created a considerable demand for electric motors. The Swiss government kept a sharp watch on the development of the electrical power industry in Switzerland during the war and large electrical machines could not be sold or delivered without its permission. The demand for motors will grow as there is a factory of some kind in almost every village (S. C. R. 17b).[2]

Electrification of Swiss Railroads Completed

The demand for electrical power in Switzerland will be strengthened by the now seriously contemplated electrification of the Swiss railroads. The serious coal shortage that has overtaken Switzerland as the result of the war now seems to have forced the hand of the government, and a close investigation has been made of all the factors that might influence the early development of the scheme. Pre-war estimates had put the cost of such an enterprise at approximately $100,000,000, excluding the purchase of the electric locomotives. Taking into consideration the increased price of all railroad material and electrical equipment, it is now expected that the enterprise cannot be completed much below $150,000,000. As it is contemplated to proceed slowly, this expense can be distributed over a period of approximately 30 years.

The amount of water power required has been estimated at 200,000 hp. at the axis of the turbines, with a momentary maximum of 600,000 hp. Concessions have been secured for obtaining the required power at several rivers. Other power sites will be acquired and it is expected that 150,000 hp. at the turbines can be obtained, which will be sufficient for three-quarters of the system. Additional power may be secured in coöperation with municipal power stations. The cost of the locomotives is estimated at $90,000,000. On the present basis Switzerland will spend annually $5,000,000 for electrifying the existing system, $800,000 for new electrical lines, $7,200,000 for works of completion and $5,400,000 for rolling stock, making a grand total of $18,400,000 every year.

Vice Consul R. E. Schoenfeld in Berne, in forwarding this news, adds that the Swiss government sees great difficulties in financing the project in Switzerland and that rumors have been published in the Swiss press that the money, or a large part of it, might be obtained in the United States. These rumors so far have been neither confirmed nor contradicted. If the United States should be induced to provide the means for this vast enterprise, it is to be expected that much of the electrical equipment would be supplied by this country (C. R. 262).

Electrical Salt Extraction in Norway

Where electrical power is cheap, as in Norway, there will be always a tendency to broaden its application. Experiments were made in that country with a view to extracting salt from sea water by electrical means. These proved successful, and it is now intended to build two salt-extracting factories, one in the west and one in the north of Norway. Each factory is expected to produce 50,000 tons of salt per year. The cost of the undertaking will amount to $5,360,000, and 6500 hp will be required in each instance (C. R. 240).

Brazil, which has made great industrial progress during recent years, is dependent on imports for a large part of its fuel, and in 1913 more than 2,530,000 metric tons of coal was imported. This import was cut by the war to 877,000 tons in 1917. Naturally, Brazil has felt the situation acutely and coal prices have become practically prohibitive. The Brazilian coal deposits are not always located conveniently for transportation and so are of use only to comparatively small districts. During the war much wood was burned to replace coal.

To solve its fuel problem completely, Brazil will have to make an extensive use of its dormant natural powers. There are great hydro-electric possibilities along the Rio Grande, Tiete, Parana, Paranapanema and Picaicaba. Government engineers have estimated that 1,876,300 hp. can be generated from the principal waterfalls of the State of Sao Paulo alone. The City of Sao Paulo has a hydro-electric central station that supplies power to the industrial enterprises in the city and its neighborhood. The question of placing great central stations in the coal-mining districts and distributing the power by high-tension transmission lines does not seem to have been considered yet.

American Electric-Station Equipment in South America

American electric-station equipment is gaining ground in South America. The two power stations in the City of Valencia, Venezuela, are both equipped completely with American power machinery, as is the tramway company of the same city. The first of these power companies has a capital of $270,000, and the other is capitalized at $154,400. Both are under the control of Venezuelan interests. The power is generated with the assistance of waterfalls near the city. The first-named undertaking supplies the power for the local tramway enterprise. The demand for electrical power has grown very rapidly in the city, and it will soon become necessary to add to the existing facilities by tapping other falls in the vicinity (C. R. 260).

The very satisfactory condition of the New Zealand electrical power industry can be judged from the report for 1918 of the Wellington Electric Light and Power Plant, an enterprise under municipal control. On a total capital investment of $1,071,300 a net profit of $141,707 was made, or 13 per cent. This was obtained after deducting interest on loans, public and private lighting, depreciation, etc. On Mar. 31, 1918, there had been made 10,384 lighting connections, as against 9454 on the same date the year before; further, there had been made 4878 heating connections against 4003, and 378 power connections against 362, or a total gain of 1821 connections. The enterprise had great difficulty in securing the supplies required for upkeep and extension of the service (C. R. 233).

At some day not far distant the seven nations of humanity will unite and blend like the seven colors of the prism into one celestial radiant whole, and beneath the majestic rainbow of the "United People of Europe" the enraptured world will dwell forever lapped in the miracle of eternal peace.—*Victor Hugo* in 1852.

[2] S. C. R. indicates "Supplement, Commerce Reports."

Yarway Automatic Boiler Skimmer

When water is brought to the boiling point in a vessel, more or less scum will float on the surface, depending upon the character of the water. When the water is used for boiler feed, if this floating material is not removed, it soon settles and becomes attached

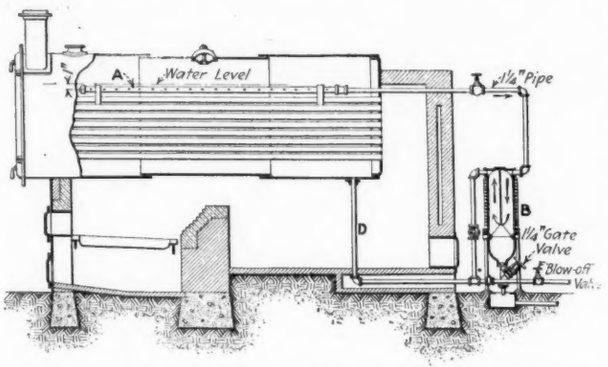


FIG. 1. SKIMMER APPLIED TO A RETURN-TUBULAR BOILER

to the shell and tubes of the boiler and trouble with scale results.

Several types of surface blowoffs have been devised to remove this floating scum, one of which is the Yarway automatic boiler skimmer, made by the Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. This skimmer consists essentially of two parts: The skimmer pipe, placed in the boiler; and the precipitator, placed on the outside of the boiler, and in which the scum and sediment are separated from the water.

Various designs of skimmers are provided, suited to different types of boilers. In Fig. 1 is shown the skimmer as applied to a return-tubular boiler. This

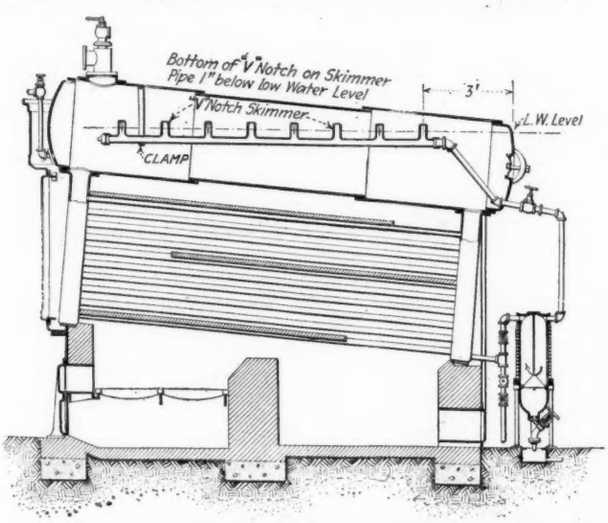


FIG. 2. ARRANGEMENT OF SKIMMER IN WATER-TUBE BOILER

skimmer consists of a 1¼-in. pipe *A* perforated with small holes along the top and sides. This pipe is supported horizontally about ½ in. below the normal water line. It connects to a pipe of the same size which communicates with the inlet connection of the collector *B*, which is divided by a baffle plate. A return pipe connects the outlet of the collector with the boiler by means of the blowoff pipe *D*.

The action of the skimmer is as follows: When the boiler is in operation, the difference between the temperature of the water in the boiler and that in the collector starts a siphonic action and sets up a circulation through the skimmer in the direction of the arrow.

As the water circulating in the boiler sweeps past the holes in the skimmer pipe, a portion is drawn into the circulating pipe, carrying scum and sediment with it over into the collector. As the water descends it strikes a deflecting cone and passes upward on the other side of the deflecting plate.

As the velocity of the water is greatly reduced during its passage through the collector, because of its large area, the heavier sediment settles to the bottom of the chamber below the deflecting cone, where there is no flow, and the water returns to the boiler without the impurities.

When the skimmer is used with water-tube and vertical fire-tube boilers, the design of the skim-

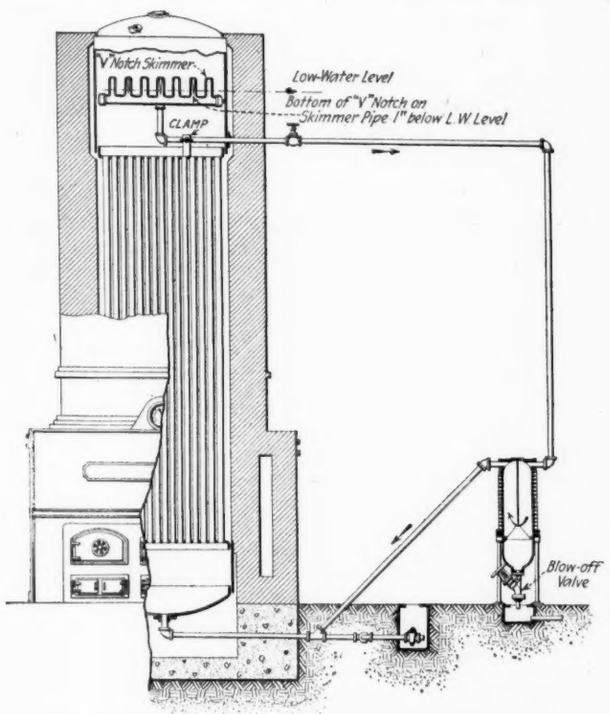


FIG. 3. SKIMMER USED WITH VERTICAL BOILER

mer is different, as the headroom in the drum of the one and the upper portion of the shell in the other type of boiler permit of the use of V-notch tubes, as shown in Figs. 2 and 3. This design of skimmer consists of a cast-iron skimmer head, and each vertical pipe is made with a V-notch opening on one side only, and the pipes are arranged so that the V-notch openings alternate, thus permitting scum from both sides of the skimmer to be drawn into the pipe and circulated through the collector.

In the skimmer used with a vertical boiler the V-notch tubes are arranged as arms spaced 90 deg. as shown in Fig. 3. These vertical tubes are so placed in the boiler that the bottoms of the V-notches are one inch below the low-water level.

The operation of the skimmer in all installations is the same as with the return-tubular boiler.

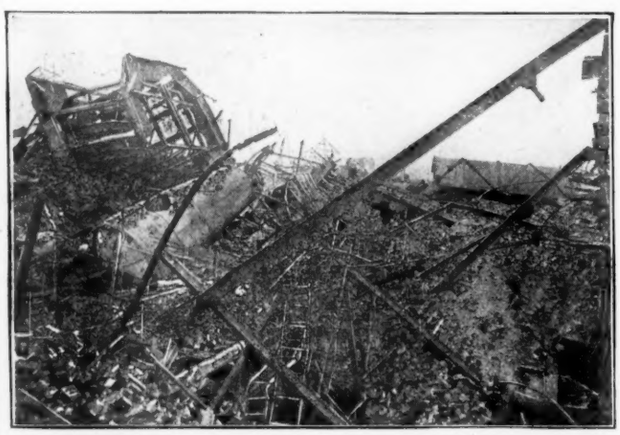
The Ruined Coal Mines of Lens

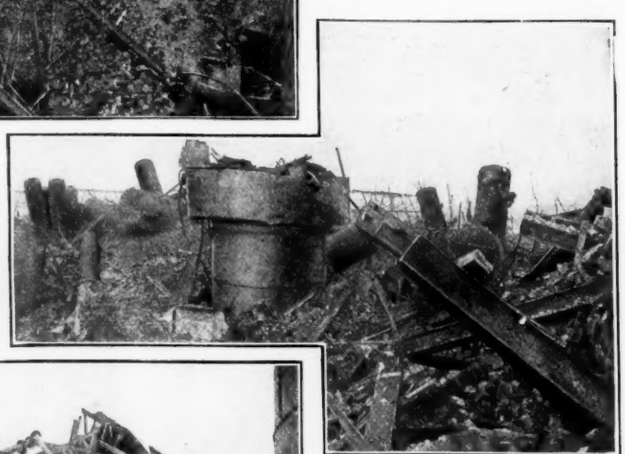
BY

ARTHUR J. BALDWIN

I HAVE seen Lens. At least, I have seen where Lens used to be. I was in Europe when the armistice was signed. Through the courtesy of the General Staff of the British Army and as a guest of the British Ministry of Information, I was taken over the battlefields immediately following the enforced retirement of the German army. The devastated area of France is indescribable. It is impossible to see this except under government auspices. There are no railroads for transportation; there are no hotels, no place to sleep or to eat. Furthermore, there are no privately owned automobiles in France. Everything must be done under the military.

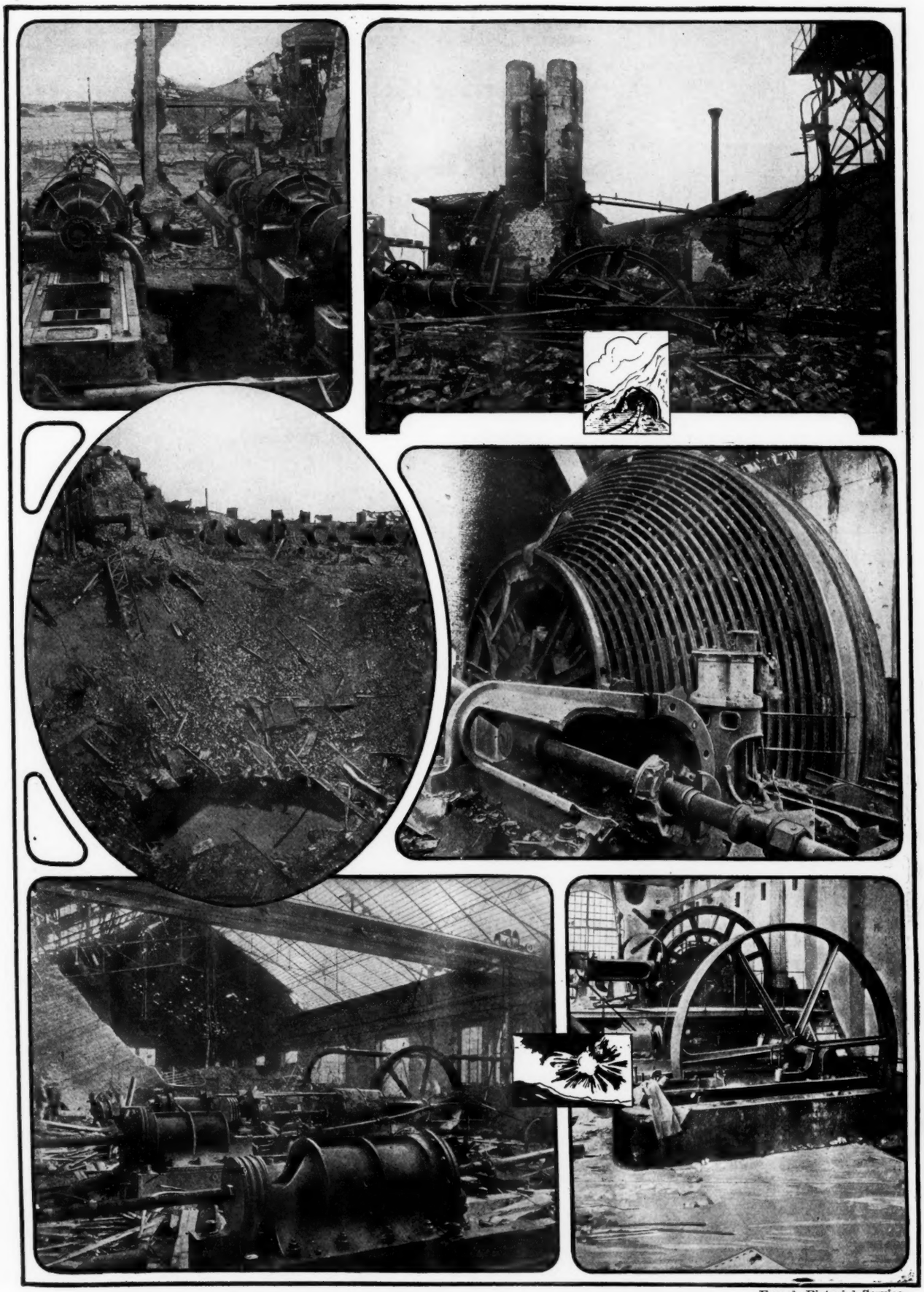
Lens is the center of one of the great coal-producing regions of France. There were formerly 180,000 inhabitants living in comfortable homes and finding their chief employment in the mines of that region. Those homes are gone. There is nothing there. Where the Cathedral of Lens once stood there is a pile of dust. In the struggle for the possession of these coal fields the houses were used by the Germans as shelter. The soldiers were billeted in the cellars. The ruined walls furnished concealment to German batteries. German pillboxes of solid concrete were built near the shattered ruins in the hope of concealing their location by the general devastation about them. This occupation caused a continuous rain of shells from heavy guns of all caliber until the very city has been wiped from existence and nothing is left excepting piles of brick and stone and dust and timber. What was not destroyed by the English in the bombardment was obliterated by the Germans before they left. Power plants were blown up, mine shafts were destroyed, heavy charges of explosives were let loose at great depth in the mines so that the underground workings were destroyed, and the river was diverted so that the mines were flooded. There is no salvage in the machinery as can be readily seen from the accompanying illustrations. It is a great task to again open up this section. In the first place there is no transportation. There are no homes for the workmen. The people who used to be workmen in this section are all scattered, and there is nothing there for them to come back to. The mine shafts will have to be constructed anew, and the power plants, hoisting machinery and the thousand details of mining will all have to be established over again. Not this year or next, nor within the next three years, will it be possible to obtain a pound of coal for the industries of France from this region.





French Pictorial Service

The pictures show all that was left of the power plants of some of the mine heads.



French Pictorial Service

THE ACCOMPLISHMENT OF DELIBERATE FRIGHTFULNESS. COMPLETE DESTRUCTION

Testing Single-Phase Watt-Hour Meters Using a Rotating Standard

by

P. B. Findley

The construction of the rotating standard watt-meter is described and its application to testing single-phase watt-hour meters discussed.

A ROTATING standard is simply a watt-hour meter having a pointer on the upper end of its shaft and arranged so as to operate on a number of currents and voltage combinations by turning a switch. Inherently, its accuracy is not as permanent as that of a wattmeter, so that if in constant use it should be calibrated at least once a month. If used intermittently it will retain its accuracy much longer. For the industrial plant the best arrangement would be to have the calibrating done by the manufacturer before the periodic tests of the service meters, say every six months. In Fig. 2 is shown a single-phase rotating standard. *P* and *P* are the potential-coil terminals, *C* and *C* the current-coil terminals and *S* the switch for connecting the meter element for different current values. The large hand *H* is connected directly to the meter shaft, consequently rotates at the same speed. The small hand *h* is geared to the large hand in such a ratio that for one revolution of the latter the former moves one division, therefore the small hand indicates the number of complete revolutions made by hand *H*. The fraction of a revolution made by the large hand is read directly from the large scale, which is divided into 100 equal parts, hence can be accurately read to 0.01 part of a revolution.

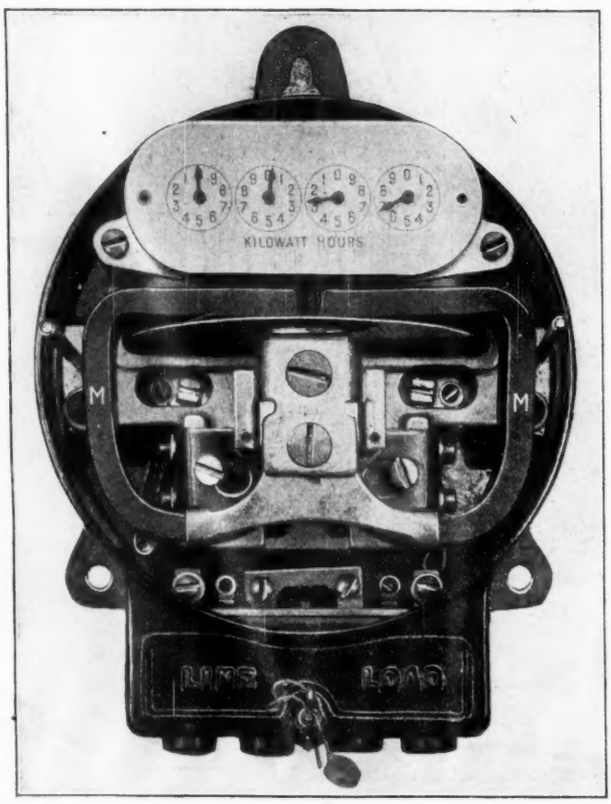


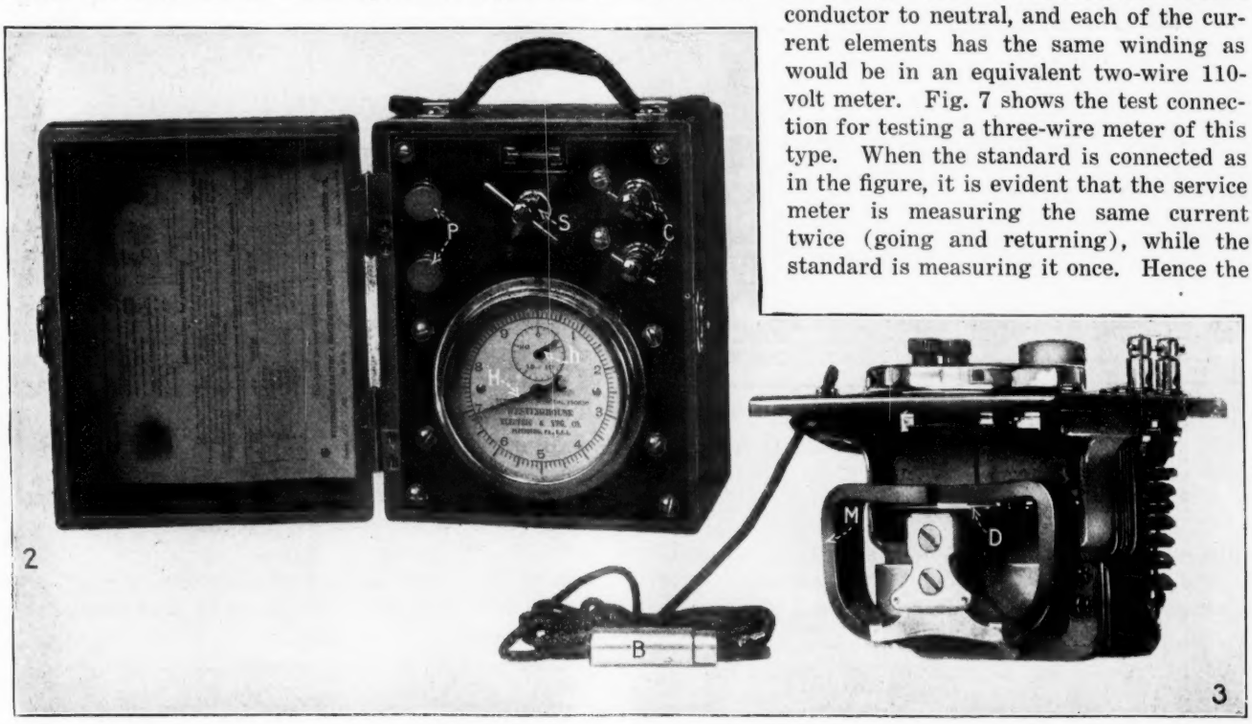
FIG. 1. SINGLE-PHASE WATT-HOUR METER WITH COVER REMOVED

Fig. 3 is a view of the meter element of the rotating standard shown in Fig. 2. It can be seen that the disk *D* and permanent magnets *M* are similar to those used in the single-phase meter, Fig. 1, which is the instrument described in the article, "Testing Single-Phase Watt-Hour Meters Using an Indicating Wattmeter," in the Jan. 28 issue. The push-button *B*, Fig. 3, connected to the meter through a flexible cord, is used to control the starting and stopping of the instrument when making a test of the service meter. In making a test on a watt-hour meter the first thing to do is to inspect the meter to see that it is in the proper operating condition as outlined in the article referred to, then the number of revolutions that the service meter will make at the different test loads is determined. When the watt-hour constant K_h of the service meter has been found, the speed N for a load of P watts is $N = \frac{P}{60K_h}$. In order to simplify construction, most manufacturers build all sizes of meters for the same full-load speed; in the case of the alternating-current meters under consideration this is 25 r.p.m. All rotating standards should have a push-button *B* connected by a long flexible two-

Note. The concluding words in the title to the article on Testing Single-Phase Watt-Hour Meters in last week's *Power* should have read "Using an Indicating Wattmeter."—Editor.

conductor cord in the voltage circuit, as in Fig. 3. This allows the meter to be started and stopped while the tester is observing the disk of the service meter. In making a test on a service meter the pointer of the standard is set to zero, and when a mark on the disk of the service meter passes a point such as the tip of one of the magnets, the button is pressed and the rotating standard started. When a specified number of revolutions of the service-meter disk is completed, the button is released and the standard stops. The error of the service meter is then $E = \frac{N \times 100}{M} - 100$, where E = per cent. error of service meter, N = revolutions of service meter, and M = revolutions of standard meter.

The foregoing formula is true only when the two meters are rated at the same speed for equal loads.



FIGS. 2 AND 3. SINGLE-PHASE ROTATING STANDARD COMPLETE AND METER ELEMENT FOR SAME

Thus all Westinghouse alternating-current meters run at 25 r.p.m. at rated load: for example, a 10-ampere 200-volt service meter runs 25 r.p.m. at 2000 watts; a rotating standard meter connected for 40 amperes 100 volts runs 25 r.p.m. at 4000 watts. When it is necessary to use standard and service meters that have different speeds at equal loads, the simplest way is to employ a conversion table furnished by the manufacturers of the standard meter.

The simplest form of meter to test is one that is self-contained, that is, uses no transformers. Typical connection diagrams are given in Figs 4, 5, 6 and 7. Fig. 4 shows the connections for testing the type of single-phase watt-hour meter under consideration in sizes of 5 to 80 amperes. In single-phase watt-hour meters of 100-ampere capacity and up to 300-ampere, one of the potential-coil connections is made outside the meter, as in Fig. 5.

The basic principle is of course to connect the current coil of the standard in series with those of the service meter and the voltage coil across the line outside the service meter, as indicated in the figures. Connections should be transposed if necessary so that the standard meter runs forward; otherwise its friction compensation will act against rotation and make it run slow.

A three-wire meter has four current coils; that is, each of the current coils of the two-wire type is split, one-half of each being in each outer wire. The voltage coil is connected across the outer wires, not from one wire to neutral, as in the direct-current meters. Hence a meter of this type is tested as a two-wire meter. Fig. 6 gives the connections for testing a three-wire single-phase watt-hour meter with a rotating standard. It will be seen that these connections are the same as those for the two-wire meter in Fig. 4.

Some types of three-wire single-phase watt-hour meters have the voltage coil connected from one outside conductor to neutral, and each of the current elements has the same winding as would be in an equivalent two-wire 110-volt meter. Fig. 7 shows the test connection for testing a three-wire meter of this type. When the standard is connected as in the figure, it is evident that the service meter is measuring the same current twice (going and returning), while the standard is measuring it once. Hence the service meter will rotate about twice as fast as the standard meter, and therefore its revolutions should be divided by 2 before comparing with the standard. When using the formulas involving K_h, care should be taken that this value represents the watt-hours measured by the combination of the voltage coil and one current coil. Since the difference between the right and wrong values is 2:1, a rough test will show whether the value used is correct or whether it should be doubled or halved.

Current and potential transformers are used with meters when either quantity is too large to handle with convenience or safety in the confined space of a meter mechanism. The transformers become parts of the instrument as far as accuracy is concerned, and hence their error must be taken into account. This can best be done by calibrating the entire group as a unit. For voltages up to 220, and sometimes to 550, the potential transformers are omitted. The portable transformers connected to the standard meter are very accurate, and are supplied with correction data, which

should be used to correct the reading of the rotating standard before applying it to determine the accuracy of the service installation.

The permanency of instrument transformers is so high that with good usage the ratio can be relied on for five years without rechecking. Good usage means steadiness, since an artificial, rheostatic, load is difficult to arrange for voltages above 220.

Since single-phase three-wire distribution is rarely used except on 110- to 220-volt service, potential transformers are not used. Current transformers, however, may be used for heavy currents. Sometimes a single

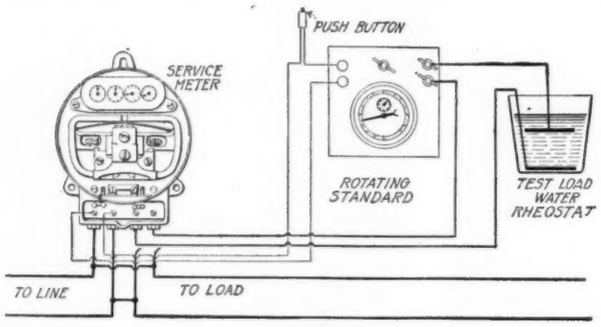


FIG. 4

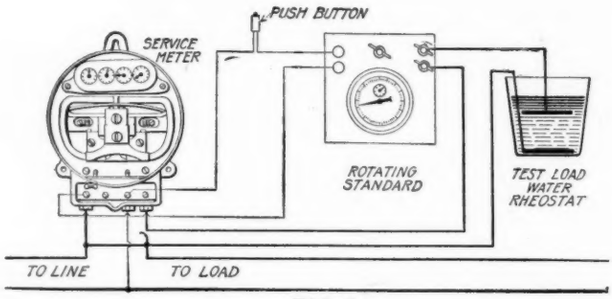


FIG. 5

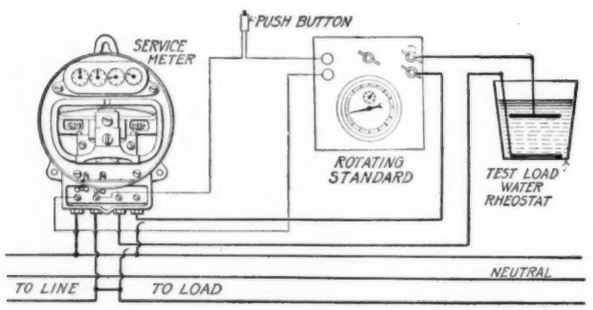


FIG. 6

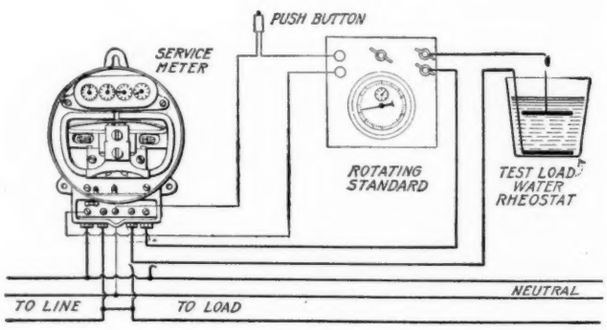


FIG. 7

FIGS. 4 TO 7. DIAGRAMS OF CONNECTIONS FOR TESTING SINGLE-PHASE WATT-HOUR METERS

that they are not overloaded, that the current transformer secondary is always short-circuited unless connected through an instrument, as long as the primary is carrying current, and that no severe line short-circuits have occurred. If these conditions are met, it is practicable to test service meters by connecting the standard in circuit with the meter alone.

When a meter on a high-tension circuit is to be tested, its potential coil can be energized from its transformer, as in service. Its current supply, however, can be obtained from a step-down transformer, whose secondary gives about 110 volts. This method is used where the connected load is not suitable in amount or current transformer with two primaries and one secondary is used, but the testing circuit is virtually the same.

Tests at low power factors need rarely be made of meters in service, unless the connected load furnishes a suitable load. Occasionally, however, such a test must be made. For routine testing of this sort, usually the voltage is thrown out of phase by a phase-shifting transformer. This transformer has primary windings for two- or three-phase supply and a movable secondary winding that can be shifted so as to bring it part way between the primary windings. Thus the phase of the current winding's voltage will lie between that of the

Dept. Drafting Office Location 2nd floor E - Janitors Closet
Apparatus Served Lights and Blue Print Machine
Make Whse Type O.A. Style No. 161373E Ser. No. 2729903 Date Purchased 1-15-18
Rating Volts 100 Amp. per Line 5 KW 1/2 RPM Full Load 25 Watt-hr Per Rev. 0.333
Transformers — Current: Ser Nos. 165917 Line Amp. 100 Ratio 20/1
Transformers — Potential: Ser Nos. — Line Volts — Ratio —

Date of Test	Light Load Observe Time of 3 Rev (N) 3600 KsN 3600					Full Load Observe Time of 20 Rev 3600 KsN 24000			Service Transformers	
	No Load	Std. Watts	Time Sec.	Error %	Tester	Std. Watts	Time Sec.	Error %	Tested	Not Tested
Perfect	OK	50	72	0	P.B.F.	500	48	0		✓
1-10-18	✓	50	71.3	+1	J.S.B.	500	46.1	+4		✓
						500	47.6	+.84		✓

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FIG. 8. WATT-HOUR METER RECORD CARD WHEN TESTING WITH INDICATING WATTMETER

Dept. Drafting Office Location 2nd floor E-Janitors Closet
Apparatus Served Lights and Blue Print Machine
Make Whse Type O.A. Style No. 161373E Ser. No. 2729903 Date Purchased 1-15-18
Rating Volts 100 Amp. per Line 5 KW 1/2 RPM Full Load 25 Watt-hr Per Rev. 0.333
Transformers — Current: Ser Nos. 165917 Line Amp. 100 Ratio 20/1
Transformers — Potential: Ser. Nos. — Line Volts — Ratio —

Date of Test	Light Load Set Std. to 5 Amp. Multiply Std. Read. by — Observe 3 Rev. of Svc. Meter				Full Load Set Std. to 5 Amp. Multiply Std. Read by — Observe 20 Rev. of Svc. Meter			Svc. Transf Tested	Repairs
	No Load	Standard Read	Standard Corr.	Error	Tester	Standard Read	Standard Corr	Error		
Perfect	OK	3	3	0	P.B.F.	20	20	0	No	
	✓	2.97	2.97	+1	J.S.B.	19.20	19.20	+4	No	No
						19.85	19.85	1985	No	No

These columns continued on reverse

FIG. 9. WATT-HOUR METER RECORD CARD WHEN TESTING WITH ROTATING STANDARD

primaries, as desired. In testing single-phase watt-hour meters, the following points should be borne in mind:

The secondary of every current transformer should be short-circuited at all times except when it is connected through the current-coil of an instrument.

To test a service meter, connect the potential coil of the indicating, wattmeter or rotating standard across the points where the voltage coil of the service meter is connected, and the current coil of the test instrument in series with the current connections of the service meter. If connection is made on the line side of the instrument transformers, the service-meter adjustment will compensate for transformer error.

Before taking readings make sure that all rotating instruments turn forward.

Make sure before making any adjustments that the conditions found are not due to any of the following causes:

Condition Found	Probable Cause
Slow on full or light loads	Short-circuit in current or potential coils
Slow on light load	Defective bearing; excessive friction in register train
Fast on full or light loads	Weakened magnets; short-circuit in external reactance in potential circuit (if used)
Will not run	Bent shaft or disk; open potential or current coil

Tests of single-phase meters should be made periodically, at least as often as the following schedule: Up to and including 25-ampere capacity, once every 36 months; above 25-ampere capacity, once every 24 months. Where vibration is severe or high accuracy is important, tests should be made as often as every month. A record card for each meter similar to that shown in Figs. 8 and 9, will be found very useful in keeping track of meter performance.

Meter manufacturers have experts on the road to assist users in getting the best possible service from their meters. In a day's time spent with one of these experts, the isolated-plant man can pick up enough practical points applying to his own installation to be able to take care of any ordinary maintenance. Bad cases such as burnouts, short- and open-circuits, should in general be returned to the manufacturer for repair and recalibration.

There is a large demand for electrical power in central Texas close to the Texas lignite beds. Water is rarely present in sufficient quantities for condensing purposes in connection with steam-turbine power plants in these regions. It looks as though the future supply of power for central Texas must come from lignite, used in the raw state in by-product producer-gas plants, as carbonized lignite on automatic stokers under boilers or in power-gas producers, or in a gas engine as surplus gas from the carbonizing process to which the lignite is subjected.

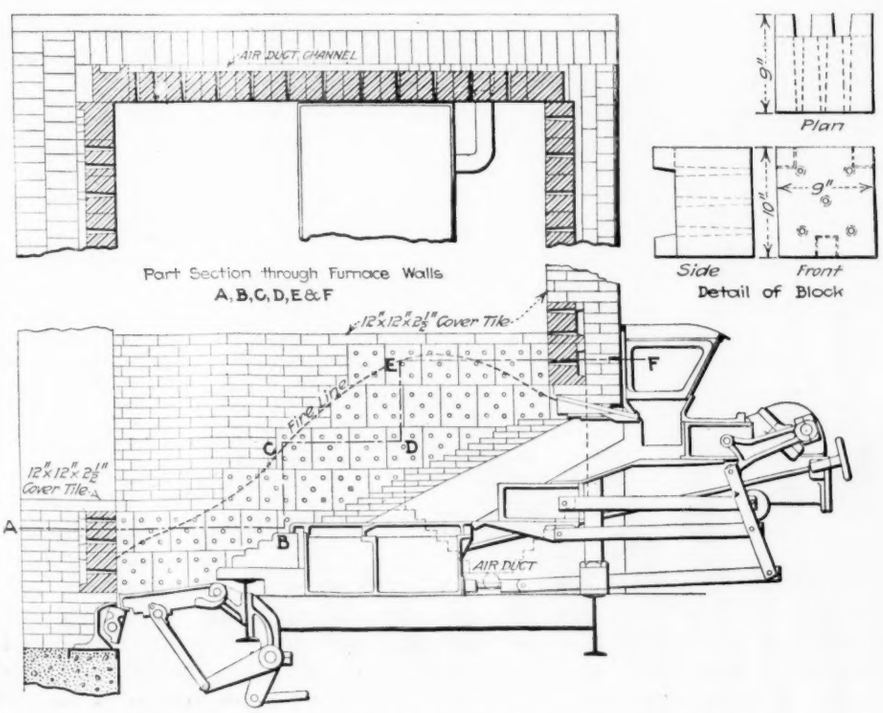
Drake Nonclinkering Furnace Blocks

Not only is it good engineering to so design a boiler furnace that the most economical combustion of the coal can be obtained, but the item of upkeep should not be overlooked. Every engineer and fireman know that considerable trouble is caused by clinkers forming on the side walls and on the front of the bridge-wall. If these are left attached to the brickwork the area of the furnace is reduced, and if the clinkers are knocked off the brickwork will be injured.

There have been several methods employed for the introduction of air at the fire level for the purpose of cooling the brickwork at that point and so preventing ashes from fusing and sticking to the furnace lining. In the method employed by Sleicher & Drake, 5 Beekman St., New York City, special firebricks are used in the furnace construction, each 9 x 10 in. on the face, and 9 in. from the face to the outside surface of the three lugs on the back of each block. These lugs form an air duct, from which air is supplied to the five tapered holes in each block.

Not only are these blocks used in the side walls, but they are also placed in the setting at the front of the furnace above the fire and at the rear end of the furnace, in the bridge-wall. An air duct connects a windbox with the air-duct chamber at the back of the perforated blocks, and through these channels air is supplied to the openings in the blocks. A damper permits of regulating the air supply to suit conditions. The illustration shows how the blocks are installed, and details of their construction are given. The top of the air-duct channel is sealed by cover tile 2½ in. thick.

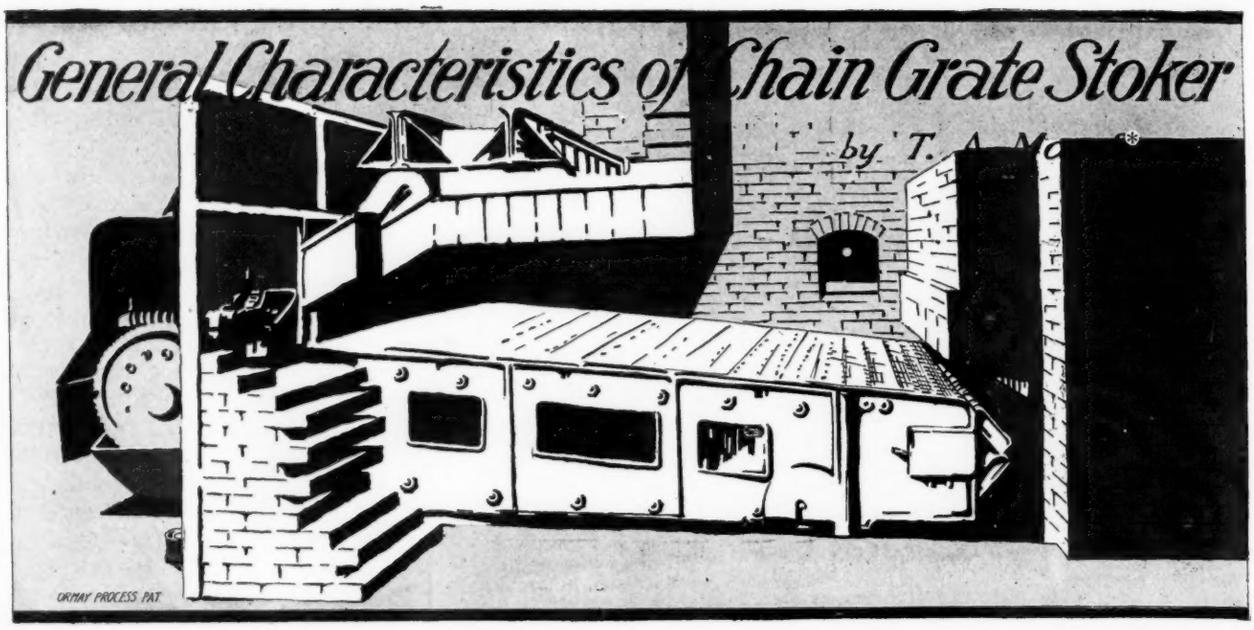
In operation the air from the windbox passes to the channels back of the brick and escapes through the openings in the blocks, absorbing some of the heat of the bricks, the idea being that as the bricks are kept comparatively cool, adhering clinkers will be prevented.



APPLICATION AND DETAILS OF THE DRAKE FURNACE BLOCKS

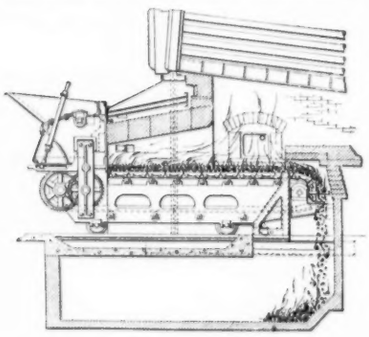
General Characteristics of Chain Grate Stoker

by T. A. Mo*

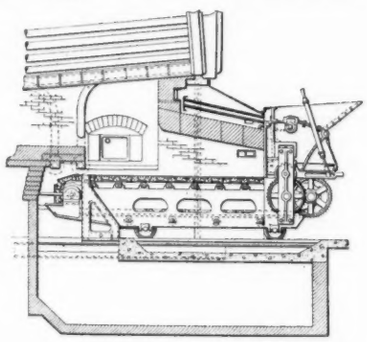


SIMPLICITY, ease of operation and high efficiency over a wide range of operating conditions have been responsible for the installation of a large number of chain grates. In the United States alone several millions of boiler-horsepower are served by this type of stoker. In spite of the number of installations, comparatively little has been written on the characteristics of the chain grate and recent developments in this stoker and the furnace serving it.

In early chain-grate practice it was impossible to keep the fuel bed at the rear of the stoker as dense as at the front. This was obviously wrong as large volumes of excess air infiltrated through the thin fuel bed at the rear. The introduction of the waterback improved operating conditions. When properly set it permits compression of the fuel bed, and makes it possible to obtain the desired density at the rear of the grate. To a certain extent this is under the control of the operator. Excess air around the rear of the grate is eliminated and special plates shut it off at the sides, so that 13 to 16 per cent. of CO_2 is not unusual. Water-backs also help in retaining the coke and in reducing the combustible in the refuse to a lower percentage than was possible with the early installations that did not have this equipment.

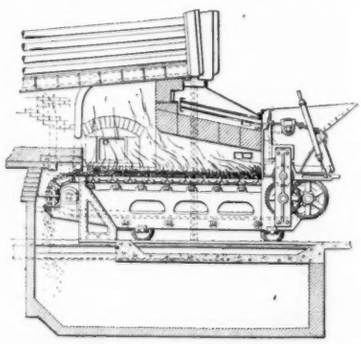


In some quarters the opinion has prevailed that boiler operation appreciably below normal rating means low efficiency. The basis for this opinion probably is due to experience in hand-fired practice, where it is difficult to carry a thin, light fire and keep it free from holes and excess air. It perhaps is not generally appreciated that chain grates do carry light loads efficiently. In fact, with furnaces of limited design the economy is better than can be obtained from these same limited furnaces at the higher rates of combustion. Ratings below normal have not claimed the interest of combustion engineers, owing to the desire to obtain high overloads, so that test data for the most part relate to operation above rating. If a stoker cannot be operated efficiently at low ratings, it is a serious drawback where light loads occur for extended periods. To show what may be accomplished in this direction the accompanying table is presented. It gives results from Green chain grates under several types of boilers. It is not sufficient to remark that the chain grate will develop high efficiencies at low ratings. The cause is the interesting item. For the burning of high-volatile coals most furnaces have been designed with insufficient volume for the combustion of the gases. Usually, the furnace has from one-fifth to one-tenth of the volume needed. The average chain-grate installation in the United States has been designed



CHAIN-GRATE EFFICIENCIES AT LOW RATING

Type of Boiler	Coal Burned per Sq.Ft. per Hr., Lb.	Furnace Draft, In. of Water	Per Cent. Rating	Combined Efficiency
Edge Moor.....	16.88	0.16	113	81.9
Stirling.....	16.50	0.09	107	78.3
Stirling.....	14.40	0.10	91	77.4
B. & W.....	7.90	0.03	57	78.4
Geary.....	20.00	0.18	105	77.5



*Chief Engineer of Green Engineering Co

and provided with draft to burn 25 to 40 lb. of coal per square foot of grate area per hour, with a furnace volume capable of obtaining complete combustion from only about 10 lb. of coal.

In Europe, where there are a great many chain-grate installations, the practice follows the idea of large grate area and low combustion rates. Normal loads are carried with combustion rates of from 10 to 15 lb. per square foot of grate area per hour, while peaks are carried with combustion rates of two to three times this amount. Naturally, the efficiency of combustion, or true furnace efficiency, is superior to that obtained over a higher range of combustion rates, and since efficient boilers and economizers have been developed also in Europe, there is little wonder that over-all efficiencies are high. Low combustion rates permit complete combustion of the gases in the furnace without the usual 5 to 15 per cent. hydrocarbon, or so-called unaccounted for, loss. By the same reasoning it is evident that if furnaces are designed with volumes great enough to permit the complete burning of the gases at high ratings, high efficiencies will also be obtained at high ratings. With furnaces having a combustion space of 10 to 24 cu.ft. per square foot of grate area, chain grates are developing combined efficiencies of from 70 to 80 per cent., which decrease only as the efficiency of heat absorption of the boiler decreases.

In the earlier chain-grate installations it was difficult to obtain as high as 12 per cent. CO_2 on account of the thin fuel bed at the rear, and the efficiency was actually higher if lower CO_2 of about 10 per cent. was carried. This is direct evidence of insufficient furnace volume.

With modern chain-grate furnaces, 14 per cent. CO_2 may be carried during regular operating periods and the maximum furnace efficiency corresponds with the maximum CO_2 up to the point where CO is developed. Modern practice has, therefore, increased the combined efficiency of the unit approximately 10 per cent. on the average, largely by an agency separate from the stoker itself, the furnace. True, the stoker must be constructed with air seals, waterback and ledge plates to prevent excess air, but this also is part of modern chain-grate design and construction.

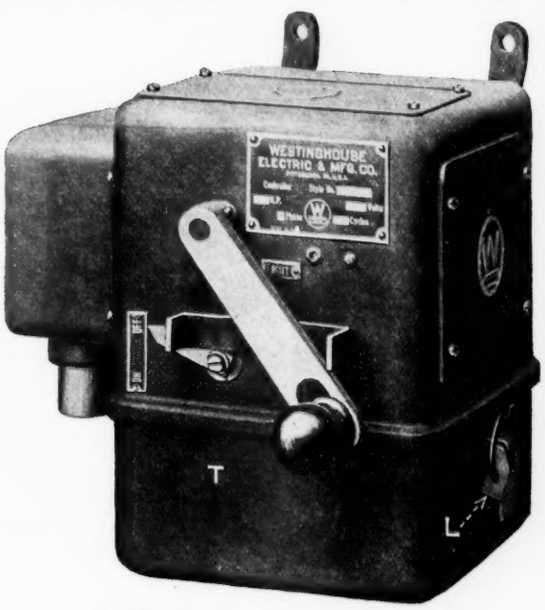
Other well-known characteristics of chain grates are continuous ash discharge, minimum clinker, ability to burn low-grade coals and lignites, grate surface always clean, low labor requirements and power for auxiliaries less than ½ of 1 per cent. of that developed. The chain grate covers an important field in combustion service, and it is certain that by a study of the stoker, the furnace and the heat absorber separately, there is opportunity for improvement in operating efficiencies.

Quick-Make Starting Switch

One of the new equipments brought out during the last year is a quick-make and quick-break switch (see illustration), designed for use where three-phase 220-, 440- and 550-volt squirrel-cage motors of capacities from 2.5 to 25 hp. are started with full-line voltage. In addition to being a motor-starting switch, it can also be used to control feeder circuits up to 100-ampere capacity. It may be supplied in any of the following combinations for either hand or shipper-rod operations: (a) Nonautomatic switch; (b) switch with low-voltage protection; (c) switch with inverse time-element overload protection; and (d) full automatic switch with low-voltage and inverse time-element overload protection.

On account of the positive action of the contacts this switch is especially suitable for shipper-rod operation. It is impossible for the operator to retard the motion of the contacts after they have started to close—there can be no "teasing" of the contacts. Contacts are opened and closed in oil, thus effectually suppressing arcing.

Drawn-steel construction is used, giving maximum strength with light weight. The oil tank *T* is supported by snap-ring latches *L*. Removal of the tank



QUICK-MAKE SWITCH COMPLETE

clearly exposes the contacts and makes them easily accessible. When necessary to replace contacts, each may be removed by taking out a single screw.

The contacts and contact supports of this switch, which is built by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn., are of the same construction as used on this company's type A auto-starters and magnetic contactors. This minimizes the number of spare parts that should be carried.

The low-voltage protection not only opens the contacts on failure of power, but makes it impossible to close them again until return of voltage. A safety stop may be provided by connecting one or more push-buttons in series with the low-voltage coil.

The overload relay is the same as that used on this company's type A auto-starters. It has the inverse time-element feature and is equipped with a regulating device, adjustment of which controls the degree and duration of the overload possible on a motor or feeder circuit. This adjustment can be made without opening the switch cover.

An additional safety feature is a hand reset which makes it necessary to set the mechanism before the switch contacts can be closed. Thus protection is afforded workmen and valuable machinery which might be injured by accidental starting of the motor.

The Electrical Study Course—Two-Wire and Three-Wire Systems

Presents a general outline of the factors to be considered in problems pertaining to wiring and proceeds to show the desirability of using high voltages and also what the disadvantages are. It is then shown how both high and low voltages may be secured by the use of a three-wire system.

TO CONVEY electrical energy from the place at which it is generated to that at which it is to be applied, we make use of conductors known variously as mains, lines, systems of wiring, etc. Several considerations enter into the choice of the system to be employed and into the sizes of the conductors comprising it. In direct-current work there are essentially only two systems from which to choose: namely, the two-wire and the three-wire. It is the purpose of the present lesson to discuss their respective merits and drawbacks, but before proceeding to do so, it will be well to give some consideration to the other part of the subject: namely, the factors governing the size of conductor required for a given service. It will be found that the three-wire system is the direct outcome of the deductions to be made from such a study.

TABLE OF WIRE SIZES AND CARRYING CAPACITIES AS APPROVED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS

B. & S. Gage Number	Diameter of Wire In.	Area in Circ.-Mil.	Rubber Insulation Amperes	Other Insulations Amperes
18	0.0403	1,624	3	5
16	0.0508	2,583	6	10
14	0.0641	4,107	15	20
12	0.0808	6,530	20	25
10	0.1019	10,380	25	30
8	0.1285	16,510	35	50
6	0.1620	26,250	50	70
5	0.1819	33,100	55	80
4	0.2043	41,740	70	90
3	0.2294	52,630	80	100
2	0.2576	66,370	90	125
1	0.2893	83,690	100	150
0	0.3250	105,500	125	200
00	0.3648	133,100	150	225
000	0.4096	167,800	175	275
..	..	200,000	200	300
0000	0.4600	211,600	225	325
..	.....	300,000	275	400
..	.....	400,000	325	500
..	.....	500,000	400	600
..	.....	600,000	450	680
..	.....	700,000	500	760
..	.....	800,000	550	840
..	.....	900,000	600	920
..	.....	1,000,000	650	1000

The problems involved in the installation of any wiring may be divided into two general classes, one of which is concerned with its safety and the other with its efficiency. Under the former head are included, first, protection from injury to persons and to the wiring and its surroundings, due to accidental contact, grounds, short-circuits, and the like; and secondly, provision against the overheating of the conductors due to the current carried by them. The first object is accomplished by using wire and devices approved by competent authorities, such as boards of fire underwriters, and by installing them in accordance with the recommendations of such bodies. The heating of the conductor for a given current is dependent upon its size, and it is therefore necessary to install the correct size of wire in addition to doing it in an approved manner. Experience has indicated what are the maximum values of currents which wires of various sizes and kinds of insulation may carry without attaining unsafe temperatures. These data, as approved by the National Board of Fire Underwriters, for copper wire, are given in the accompanying table.

The efficiency of the installation depends on the losses in it, and partly on its voltage regulation. As we know, the loss in any conductor carrying current is the product of its resistance and the square of the current. Thus, if W represent the loss in watts, I the current in amperes, and R the resistance in ohms, we have $W = I^2R$. It would therefore appear that we need merely make R very small in order to reduce W to a negligible quantity, and hence make the efficiency of transmission very high. However, the size that it is practicable to use is limited by the cost of the wire and the expense of installing it. The larger the wire the more costly it and the wiring appliances would be, and the more labor it would require to install it. When the cost of electrical energy is high, it is economical to spend a relatively large sum of money for wiring, in order to keep down the losses. On the other hand, if the energy is comparatively cheap, it is less expensive to waste a considerable percentage of it than to tie up a big sum of money in large-sized conductors.

The ordinary problem of wiring, however, does not call for any extended analysis. The controlling factor is usually the drop in voltage in the line, particularly when the load consists of lamps, in which case the size of wire used must be such that there is no objectionable change in candlepower with change in load. For example, if a load consisted of three hundred 50-watt 120-volt lamps, the full-load current would be $\frac{300 \times 50}{120} = 125$ amperes. If the maximum allowable change in voltage is determined upon as being 2 volts, we would have that the resistance of the line must be $\frac{2}{125} = 0.016$ ohm. The size of wire to be used then depends upon its length. The longer it is the larger it must be in order to keep the total resistance down to the value determined.

To recapitulate, wiring problems involve the following features:

- (1) Safety
  - (A) Method of installing
    - (a) Approved wire
    - (b) Approved devices
    - (c) Approved workmanship
  - (B) Heating ..... (d) Correct size of wire
- (2) Efficiency
  - (C) Loss in line ..... (e) Size of wire
  - (D) Voltage drop in line .. (f) Size of wire

Thus it is seen that the size of wire affects the heating, line loss, and line drop, and therefore any one of these three items may be the controlling factor in the choice of the size to be used for a given current. From any of the three standpoints a larger current

calls for a larger wire. It is therefore best to restrict the current to as small a value as possible.

Now the current is dependent upon two elements—the load to be served and the voltage of the service. That is, $W = EI$, where W is the load in watts, E the voltage, and I the current required at that voltage. Consequently, for a given load the current may be reduced by increasing the voltage, and the question becomes one of how high to make the voltage. Various factors must be taken into account in making a decision, among which are, safety to operatives, increasingly

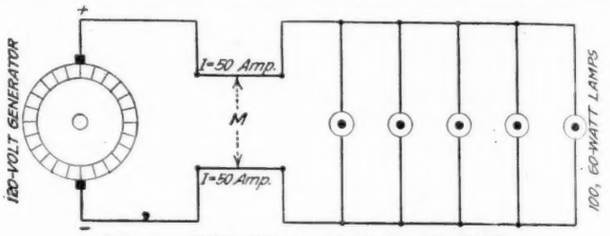


FIG. 1. TWO-WIRE 120-VOLT CIRCUIT

effective (and therefore increasingly expensive) insulation at higher voltages, possibility of obtaining apparatus to operate at the voltage chosen, and others of like kind. Since the two most extensive uses of electricity are for power and for lighting, the decision must be based upon the requirements of such services. Power is of course furnished through the medium of motors, and such machines can be constructed to operate satisfactorily at considerable voltages; the limit, in industrial direct-current work, is usually established between 500 and 600 volts, although in electric-railway work voltages up to 5000 have been used. Lamps, on the other hand, give the most satisfactory results when designed to operate in the neighborhood of 120 volts. When motors and lamps are to be supplied with power from the same service, it is almost compulsory to make the best lamp voltage the controlling element. No matter how desirable it might be to operate the motor load at 500 volts, it would be out of the question to use lamps for such a voltage without operating them in series groups, which, to say the least, is very unsatisfactory. If the motor voltage were reduced to 250 volts, it would be possible to use lamps on the service, but not advisable. The most satisfactory method is to use lamps which operate at from 110 to 125 volts. It has, however, the disadvantage of requiring a line wire designed to carry twice as much current as at the higher voltage, which even for the lighting load is a serious handicap, but which for large power service makes it almost prohibitive.

To meet these conflicting conditions a method of distribution known as the three-wire system was evolved, which differs from the ordinary circuit, requiring two wires, in the fact that it makes use of three wires as its name implies. The principle upon which it was developed may be explained as follows:

Assume that it is required to use one hundred 60-watt 120-volt lamps to furnish a certain amount of illumination. The total amount of power to be supplied would be $W = 100 \times 60 = 6000$ watts. If the load were supplied from a 120-volt two-wire system, as illustrated in Fig. 1, the current required would be $I = \frac{W}{E} = \frac{6000}{120} = 50$ amperes. If the voltage drop in the line M were to be restricted to 3 volts, its resistance would have to be $R = \frac{E}{I} = \frac{3}{50} = 0.06$ ohm, and the power lost in it would be $I^2R = (50)^2 \times 0.06 = 150$ watts. Suppose, now, that the lamps were arranged as shown in Fig. 2; that is, that they were divided into fifty groups of two lamps in series. In that case it would be necessary to impress a voltage of 240 volts across the mains in order to make the lamps burn at their proper brilliancy. The total load would be the same, and we should therefore have $I = \frac{W}{E} = \frac{6000}{240} = 25$ amperes, or half the current required at 120 volts. The difference arises from the fact that at 120 volts we have 100 paths through the lamps, each taking 60 watts, or $\frac{60}{120} = 0.5$ ampere; whereas at 240 volts we have only 50 paths, each taking that current. If we were to allow the same line loss in the latter case as in the former, we should have $(25)^2 \times R = 150$ watts, from which we find $R = \frac{150}{(25)^2} = 0.24$ ohm, a value four times as great as required before. The voltage drop in the line would be $E = IR = 25 \times 0.24 = 6$ volts, twice the value at 120 volts; but since the lamps are arranged two in series, a drop of 6 volts across the two is equivalent to a drop of 3 volts across each, the same as on the 120-volt circuit. Consequently, the resistance of the line could be increased fourfold without changing either the loss in it or the voltage drop to the lamps. The cross-section of the wire could therefore be made one-quarter of what it was, which means that only one-quarter of the weight of copper would be required, with a corresponding reduction in the cost of the installation. It may be pointed out here that a reduction to one-quarter of the cross-section is equivalent to halving the diameter. Thus, the area of

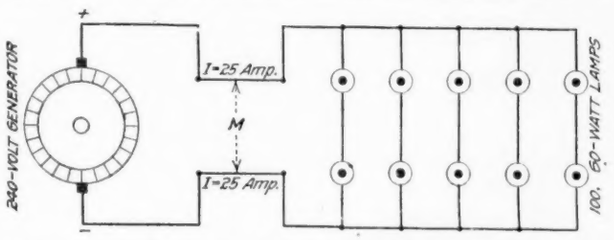


FIG. 2. TWO-WIRE 240-VOLT CIRCUIT LAMPS GROUPED TWO IN SERIES

a rod 0.4 in. in diameter would be $\pi \times (\text{radius})^2 = 3.14 \times \left(\frac{0.4}{2}\right)^2 = 0.1256$ sq.in., whereas that of a rod of half the diameter, namely, 0.2 in., would be $3.14 \times \left(\frac{0.2}{2}\right)^2 = 0.0314$ sq.in., or one-fourth of the other. That is, the area of a circle is proportional to the square of its diameter.

An arrangement of lamps such as that indicated in Fig. 2 could be operated satisfactorily if they were always required in pairs, but otherwise the scheme would not be practicable, since by turning out one lamp the other would also be extinguished. There are additional drawbacks to the series system in that the lamps must be identical, or they will not burn at the same brilliancy, a short-circuit in one results in double

normal voltage being impressed upon the other, causing it to burn out, and both lamps are extinguished if either one of them fails.

These undesirable features may be eliminated by the use of a method such as that represented in Fig. 3, which is the typical diagram of a three-wire system. Instead of using a single source of 240 volts, two sources of 120 volts each are connected in series and a connection is made at the junction *a*, and run as a third main wire to the load. It is commonly referred to as the neutral wire or merely as the neutral of the system, and the other two lines are known as the outside wires. Thus, in Fig. 3, *N* is the neutral and *A* and *B* are the outside wires. It will be noticed that a voltage of 240 volts exists between the outside wires *A* and *B*, but that that between either outside and the neutral is only 120 volts. Also that the neutral is negative in reference to one outside wire and positive in reference to the other. In a future lesson it will be shown how such a system overcomes the objectionable features of the straight series arrangement and yet retains the advantage of effecting a material saving in copper as compared with that required for the wiring in a two-wire 120-volt system.

The problem of the preceding lesson concerned three compound generators of 50 kw., 120 kw. and 200 kw. capacity respectively. The resistance of the series field

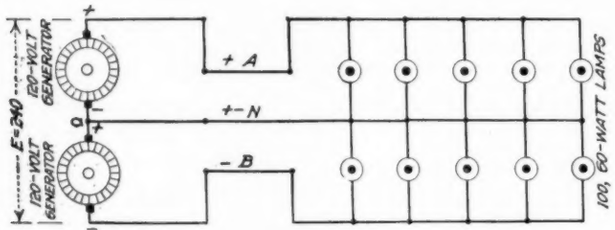


FIG. 3. THREE-WIRE 120- TO 240-VOLT CIRCUIT

of the 50-kw. machine was stated to be 0.01 ohm. It was required to determine what the resistances of the series fields of the other two machines would have to be if it was intended to operate the three generators in parallel. For any load on the generators the 100-kw. machine should deliver twice as much current as the 50-kw. one, and the 200-kw. machine four times as much, consequently the currents through their series fields should be of those values. Since all the series fields are connected across the same voltage—namely, that between the equalizer and the busbar at the other side of the fields—the resistance of the series field of the 100-kw. generator must be half that of the 50-kw. one if the current through it is to be twice as great as that through the latter. Similarly, the resistance of the 200-kw. generator would have to be one-quarter that of the smaller machine in order that its current should be four times that of the other. We therefore have that the series-field resistance of the 100-kw. generator should be $\frac{1}{2} \times 0.01 = 0.005$ ohm, and that of the 200-kw. one should be $\frac{1}{4} \times 0.01 = 0.0025$ ohm.

A line of rubber-covered wire is to be run 150 ft. to supply current to fifty 100-watt 125-volt lamps and twenty ½-hp. 125-volt motors. If the size of the wire used is that called for by the Underwriters' rules, what would be the voltage drop in the line at full load? Also, what would the loss in it be?

A Discussion of Belt Tighteners

BY CHARLES CRANE

A belt tightener, to function properly, should be so designed that it will maintain nearly the same tension on the slack side of the belt under all loads. Others should really be called adjustable idlers, for if the pulley remains in a fixed position and a heavier load comes on, the pulling side of the belt will stretch and the slack side will become more slack, which will allow it to drop away from the tightener pulley. This will relieve the tension on the belt just at the time when it should have more tension, and it will slip and have a tendency to run off. A crown-faced pulley has nothing to do with the belt running to one side, for if a tightener pulley leads a belt to one side at all, it will run in nearly the same position under all loads.

Any idler pulley may be made to lead a belt a little to either side by simply throwing the idler out of line with the center line of the belt. Imagine a belt standing still and a pulley being rolled along on it. If it is in line with the belt it will stay on, but if it be turned a little to one side it will run off. Suppose the belt moves and the pulley is held in one place but turned a little to one side, as before. It is evident that the pulley cannot run to one side, therefore it will exert a pull on the belt in the opposite direction, which will tend to run it to one side until the force exerted is counteracted by the pull of the crowned faces of the drive and driven pulleys tending to hold the belt on, in which position it will remain.

The type of tightener is unimportant so long as it is allowed to play freely and maintain an even tension on the belt; but a swing tightener—that is, a rigidly built frame lying parallel to the belt and hinged at one end to a support, the other end carrying the pulley—is preferable as it is of simple construction, plays more freely and is easier of adjustment for leading the belt.

It seems to be the universal practice to set the tightener pulley as close as possible to the driven pulley, The reason generally given, outside of it being customary, is that it gives the belt a greater arc of contact on the small pulley. With the tightener placed close to the driven pulley, an increase of load will stretch the pulling side of the belt and the extra slack will run off at the driver first. This slack having nearly the full length of the slack side of the belt, before it reaches the tightener the belt will start flapping and the tightener will play up and down. When the tightener rises quickly, it may be carried too far by its momentum, with a resultant release of the tension on the belt, allowing it to slip. With a belt running at high speed excessive flapping will often entrap a little air between the belt and the pulley face, which will greatly reduce the contact area. When the tightener is close to the driver, it will take care of the slack the instant it runs off the driver, and the belt and tightener will run much more smoothly, which will more than offset the advantage of the extra arc of contact obtained by the former method.

The great demand for radium, in connection with its scarcity, makes it perhaps the most valuable mineral. Gold is worth $20 an ounce, but an ounce of radium is estimated to be worth more than three million dollars.

EDITORIALS

Limits in Turbine Capacity

SOMEONE is trying to lay the steam turbine on the bed of Procrustes. There is in the air the question of limiting its capacity at 30,000 kilowatts. Just why the tenuous discussion should select this capacity as the limit is difficult to conjecture. It sounds like judgment made in the face of overwhelming facts; it is akin to denying the existence of Niagara Falls.

In the first place a turbo-generator must be reliable regardless of capacity. With reliability assured and cost considerations cared for, the chief reason for selecting units of various sizes or various units of the same size for a plant is to enable carrying the load throughout the day at the most economical water rate. Of course there should be units enough, or provision made, to continue service and permit of cleaning and repairing—there must be spare capacity.

Since the introduction of the turbine the trend has been upward. As unit capacity has been increased, the water rate has decreased, and with it the cost, not only of the unit itself, but of the whole station, has fallen. With the growth of large power systems supplied by a few huge stations operating in parallel, costs would be seriously affected if for the system units of 30,000 kilowatts or under were selected. True, such limit might be best for some stations or some systems; but it is idle to ask the camel to take no greater stride than the burro. Standardization is desirable until it is made abortive and retrogressive. Fixing 30,000 kilowatts as a limit for steam turbines seems to us to be of this class. The factors that will fix ultimate capacity are the physical limits, shop practice, and shipping restrictions. Capacities have now reached 70,000 kilowatts in one unit, the compound machine in the Seventy-Fourth Street Station of the Interborough Rapid Transit Company. If the load conditions warranted, no doubt the purchasers would have called for a 100,000-kilowatt machine.

Brighten Up the Boys' Home-Coming

IT HAS been said that electricity won the war. This statement no doubt can be challenged. However, electricity was one of the most potent factors in carrying on the world struggle to a successful termination for us and our Allies. There is scarcely anything that entered into the war machine in which electricity did not perform an important function. From the production of the raw materials and the conversion of them into munitions, and the utilization of these munitions at the front, we find electricity playing a master rôle. Even the plans of the master strategist would be of little use if it were not for the elaborate systems of communication made possible by the use of electricity.

The big job is done and the boys are returning to us victorious. They have done the work they were sent to do, done it heroically, in a much shorter time than expected. Many of them have paid the supreme sacrifice and now rest in the sacred soil of France. Many of those returning have been wounded and have suffered long days and weeks in the hospitals in France, and realize that they return to civil life greatly handicapped to compete with their more fortunate brothers.

When they left us gloom was cast over this country, curtailment of light and silence was the order of the day. Transport after transport, laden with our boys, silently left our shores for "Over There" without any send-off or outward demonstration of any kind. They made the trip on darkened vessels through submarine-infested waters and arrived in the darkened cities of war-saddened Europe. Now that they are returning and all restrictions are off, let us make this home-coming in keeping with the feelings of a great and victorious people, proud of the good work the boys have done. What better agent can we employ to do this than electricity?

This brighter home-coming is something we owe to the boys; it is a national duty and something that every citizen can take part in, either by letting the lights shine in his home, office, shop or plant or by the construction of large electric signs of welcome. Central stations, manufacturers, contractors and dealers, who have not already done so, can get behind this great movement by getting in touch with the International Association of Rotary Clubs, chambers of commerce and committees appointed by civic authorities and other trade associations.

What About the Pumps?

IT HAS been pointed out many times that the power-plant pump should receive the same attention that is given to steam engines and other power-plant apparatus, but it is well known that the pump in most instances is neglected and left to run itself, perhaps because it is simply constructed and seems to possess a faculty for getting on without much help from the attendant.

This neglect may be because pumps are so frequently placed in out-of-the-way places instead of where they are readily accessible. Be that as it may, it is evident that although a pump can withstand a large amount of neglect, there comes a time when difficulties will be encountered, and the blame rests with the man who is supposed to care for the pump.

First of all, a pump should be placed in a convenient, clean and well-lighted location, if possible. It will then be likely to receive some attention. Naturally, a suitable foundation will be necessary, otherwise there is danger of a leaky suction pipe, groaning of pistons and general vibrating troubles.

It will be conceded that the pump, as is true of any other machine, should be kept clean, both inside and outside. This means frequent internal inspection be-

cause the fact that the pump is operating satisfactorily today is no assurance that it will do so next week. To be reliable the machine must be kept in good repair.

Examinations are necessary in order to detect what parts are wearing, how fast they wear and to determine when to renew parts before they give out entirely and perhaps cause a shutdown. If a suitable strainer is attached to the suction pipe, there will be less valve trouble in the water end, and interior inspections may be reduced to, say, about four times a year.

Pump trouble generally occurs in one of three places—suction pipe, water end or steam end—but as certain difficulties have certain symptoms, locating the trouble is less difficult to the man who understands the machine. However, if it is necessary to run the pump faster this week than last, it indicates that the plunger needs looking after and that leakage is occurring past the packing; or it may be that a valve is hung up by some obstacle. A jerking action and pounding of the water piston indicate clogging of the suction pipe, and lack of air in the air chamber is usually evidenced by a dull thud at the end of the stroke. Thus it is seen that each trouble tells its own story by the action of the pump. A careful study of the machine will usually direct one to the cause of the trouble.

One of the greatest neglects of a steam pump is due to lack of lubrication, as on account of its location the lubrication is in many instances intermittent. The trouble is that the lubricator is allowed to run empty and remain so because someone thinks there is sufficient oil in it for hours to come. No engineer would think of lubricating the cylinder of a steam engine on a hit-and-miss plan, but that it just what is done with the majority of steam pumps in the average steam plant.

It is needless to say that a well-designed and constructed steam pump, when given proper care, will give reliable service and will not be a tax on the time of an engineer any more than any other piece of well-made machinery found in the plant.

Increased Rates for Electric Service

THE recent decision of the Railroad Commission of the State of California authorizing the California Edison Company to increase its rates for electric service is another instance showing that public utilities may expect a square deal from the public if the former render the latter an adequate service. It is worthy of note that at the hearings all parties interested were present, but not a single objection was raised to the increase in rates. President Edgerton of the commission wrote in his opinion: "I am convinced that we will be acting with entire fairness to the applicant as well as to consumers if we fix rates so as to put the applicant in approximately as good condition as it was before these abnormal increases in cost."

The attitude of the California Edison Company during the crisis has been a commendable one, in that it has made an honest effort to maintain its high standard of service without increasing its rates and only making application when an increase was absolutely necessary. This attitude, judging from the results of the decision, appears to have been one which might profitably be followed by utilities in general.

Engineers' license laws are founded on considerations of public safety, but to bring out the skill and intelligence of applicants for licenses, the inquiries have been largely directed to the applicant's knowledge of design and technicalities of engine-room practice. Now that fuel conservation is so commonly recognized to be an important question of national preservation, examiners will do well to switch some of their attention to the economics of boiler-room practice.

Exhaust steam, when available, can frequently be substituted for live steam in heating coils, etc., with but slight changes in the equipment. There is a general belief, however, that the difference in the total heat between exhaust steam at atmospheric pressure and steam at, say, one hundred pounds pressure is considerable. A glance at the steam table will show that the difference is less than forty British thermal units.

It is an engineering fact that a column of water one foot in height exerts a pressure of slightly under one-half pound per square inch, and, conversely, the pressure of half a pound per square inch will support a pound of water one foot in height. If some of the articles recently published regarding water flooding radiators are criterions, it would seem that some heating engineers have overlooked this truth.

The war has been responsible for the introduction of many new words, and a leading British paper in defining one of them said, "These men have been labeled 'pivotal,' which means that their work is a necessary preliminary to the employment of others." Practical men can realize that for many purposes the word "pivotal" is more exact and specific than "indispensable."

Although there is danger of spontaneous combustion with stored bituminous coal, it is safe to assume that after the first summer it will not catch fire unless it is disturbed, in which case the coal will heat the same as when first piled, and will catch fire as readily. Coal having a tendency to heat unduly should be let alone after storing, otherwise there is likely to be trouble.

Every engineer should have a simple boiler-room log for keeping a record of the fuel and water used, the evaporation of water in pounds per pound of coal burned and the weight of ashes obtained. Although such a record is easily kept, there are thousands of plants in which nothing is known as to the performance. Is it not about time to wake up?

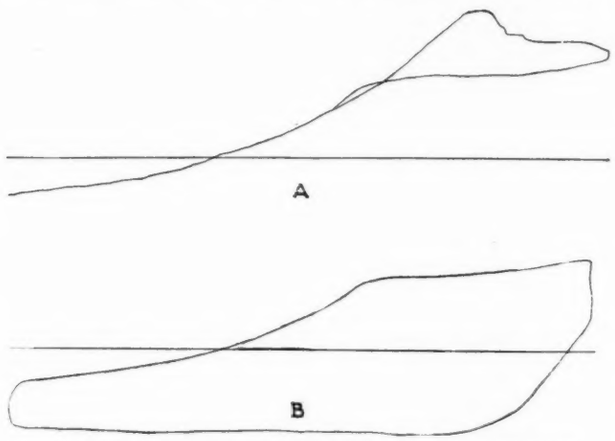
Passing laws and signing ordinances will not supply the human race with food and clothing. The man who sticks day after day to some form of productive labor is of infinitely more account than the chap who spends all his time trying to convince his fellows that the world can get along without working.

The loss of heat from the surfaces of steam pipes and cylinders is commonly termed radiation; but a part of the heat is carried off by convection, or the sweeping of air currents over the heated surfaces.

CORRESPONDENCE

Misadjustment of Exhaust Valve

The indicator diagrams shown are from the low-pressure cylinder of a 9 x 16 x 36-in. compound Corliss engine. The engine had been taken apart, and I had given instructions as to the correct manner of replacing the valves. On starting up, however, there was a bad knock in the low-pressure cylinder. The indicator justified the suspicion as to the cause of the trouble by producing diagram *A*. The crank-end exhaust valve was improperly placed and connected, so that it did not open at all. The steam was compressed to a pressure above that of the receiver, lifting the



FREAK DIAGRAM WHEN VALVE WAS IN WRONG

admission valve from its seat, producing severe "slamming" on its return. Diagram *B* was produced when the valve was put in right. VICTOR R. GAGE.

Ithaca, N. Y.

Lubricating Cylinders and Bearings

I believe it is a rare case indeed where a bearing heats because it is getting too much oil, as has been suggested. Bearings on high-speed engines, especially eccentrics, cause trouble because dirt or pieces of waste get into the oil holes which lead to the oil ways. Large eccentrics as well as crank boxes and main bearings often get hot because the oil ways have been worn down. It is necessary to provide oil grooves and also to scrape down the approach or "leading in" side.

A generous supply of oil (flooding) will cushion the pound and make it unnecessary to key up the bearings frequently. In one instance where they had been in the habit of keying up every week, I was able to reduce this to six or eight weeks. Part of this improvement was due to an improvement in the valve setting.

The most difficult cylinders to lubricate are those that get superheated steam and saturated steam alternately. I made good on one job on which others had failed because I found out that the foregoing conditions prevailed and took steps to improve the situation and to find the proper cylinder oil for the peculiar condition. With saturated steam the oil should be compounded with tallow oil, and it is advisable also to compound, slightly, oils for superheated steam because the steam is always wet when starting up and a spray of water may sometimes come over from the line even with superheated steam. W. WALDO.

Foster, Ohio.

Boiler Blowoff Valves

I have been following the discussion on blowoff valves, expecting someone of more experience to bring out what looks to me to be the vital point; namely, that one of the two valves, or a valve and cock, is for emergency use. In this state (Ohio) the law calls for two valves, or a valve and plug-cock, on boilers that carry in excess of 135 lb. steam pressure. The old through-plug style of cocks is limited to 25 lb. pressure. Some of the illustrations showing blowoff lines are fine, with plenty of room, but they cannot be so arranged with boilers set with the mud drum not more than six inches above the floor.

A few years ago I was working in a plant that had two valves on the blowoff line, and the boilers were blown down by opening the valve next to the boiler last and closing it first. This seemed the ideal way, even when the first valve began to leak, but in a few days the second one also began to leak, and the chief told me to put on a new one. The line was in a trench, and while putting on that valve with hot water all around me, I was convinced that the order of blowing down was wrong. I concluded that two valves or a valve and cock were on a blowoff line for emergency use. A cock was put next to the boiler and left open, except in emergency, therefore the wear was within the plug, and so did not affect its tightness. If we had put a valve next to the boiler and left it open, the seat would have been cut out in a short time, and if we shut and opened it every time, it would probably leak and be "no good" in case it was needed badly. Our firemen blow the boilers down once every eight hours and our blowoff line shows "drop tight" after two years' service. I will repeat what a chief, whom I was once repairman for, told me: "Keep an emergency appliance for an emergency and keep it so it will function when the emergency comes." BARCH SMITH.

Newark, Ohio.

Speaking of boiler blowoff valves, have readers noticed that the majority of manufacturers mark their valves to be placed so that the stem stuffing-box is continually subject to boiler pressure? Most of us put all valves on the other way, and I prefer to so place a blowoff valve. I use a flanged valve next to the boiler

and an asbestos packed stop-cock outside and open the stop-cock first, then the valve, because the valve is more easily handled. With this arrangement the stop-cock and packing on the valve stem may both give out and still leave the valve good. If the valve leaks it will usually leak into the line instead of out through the stuffing-box, which is just as wasteful but not so dangerous as letting it go outside.

Our valves do leak sometimes and have to be watched and taken care of, but who ever saw a valve that did not need attention? Besides, if they did not need attention, what would we do to earn our money?

Philadelphia, Penn. T. A. MARSHALL.

Making Diesel Operators from Steam Engineers

The letter by Mr. Cooke on page 27 in the issue of Jan. 7, "Making Diesel Operators from Steam Engineers," will, I feel, strike a sympathetic chord in the breasts of genuine steam engineers. Some years ago an electric plant with which I was conversant had a mixed power plant. Part of it was steam-driven and part was Diesel-engined, and all units supplied current to a common switchboard.

As the current generated was alternating, it was essential that the units be brought in step and synchronized properly. The oil sets consisted of two three-cylinder Diesel-engine units with an alternator between, and there were several of these sets. Each part of the power house—that is, the steam section and the oil section—had its own chief engineer, which is the worst possible combination. Trouble developed with the governor of one of the Diesel sets, and the chief, who I am told was an excellent machinist, was unable to remedy the trouble; so, after two or three days of agony, the general manager got the steam chief on the job.

"Have you put the indicator on to see if you can locate the trouble?" he asked the oil chief.

"I know where the trouble is," he was informed.

"Then why don't you remedy it?" the general manager asked.

"It's in the governor, but I can't seem to locate it," he replied.

Well, to summarize, the steam engineer used his own steam-engine indicator, which had a special oil-engine bushing for the cylinder, and found that the middle cylinder on one engine was not doing any work worth mentioning because no oil was being injected into it. He found, further, that a pipe scale or something of like nature had closed the extremely small oil-valve opening. After this was cleared, the governor functioned properly.

This little incident does not prove that oil engineers are not "onto their jobs," to use a slang expression, but that this oil engineer, who had come well recommended, was not as thorough a power-house operator as the steam man. In connection with the Diesel plant there was a very nice compressor plant consisting of a four-stage compressor driven by a cross-compound Corliss engine, a self-contained outfit, but who do you suppose had to look after this outfit? Not the Diesel chief, but the steam chief. I believe that there are Diesel experts and also steam-engine experts, but many are at best only throttle openers and closers; nevertheless the steam engineer that knows a power plant from start to finish need not worry at the micrometer adjustments or the "full-jeweled movement" of the Diesel.

New York City. C. W. PETERS.

Pump Valves Do Not Wear Well

From the letter by M. C. Larsen on page 30 in the issue of Jan. 7, it seems to me that his only trouble is poor material in the valves. Hard-rubber composition valves, made to resist the action of hot water, should not wear out and break in two weeks or even in two months. If there is acid or other chemicals in the water strong enough to destroy the valves in two weeks, it would also destroy the iron pipe work, therefore the fault must be in the valves.

In the plant where I am employed we have pumps working 24 hours a day handling water with an average temperature of 190 deg., and the hard-rubber valves last from one to two years, only requiring refacing a couple of times. Mr. Larsen should examine the valve seats and make sure they are level and that the springs on the stud bolts are not overstrong. I have used a metal-bound valve in the same class of work, which gave excellent results. JAMES E. NOBLE.

Portsmouth, Ont., Canada.

Methods of Banking Fires

Banking fires, as referred to in an editorial in the issue of Jan. 14, is a matter of great importance in saving time, money and labor. Pushing back the live coals to the bridge-wall and covering them over with green coal, especially soft coal, is a mistake. This kind of a bank will lie dead over night and probably Saturday afternoon and Sunday, allowing the boilers to cool down and reducing the pressure. On hauling those banked fires down again, probably one or two hours before starting time, it will take a good many shovelfuls of coal to get the pressure up to where it belongs. There are other things, however, that will waste coal. The blowoff and other valves leading from the boilers may be leaking, allowing the boilers to lose water during shutdown time; and to make up for this, one is likely to have to let a large quantity of cold water into the boilers before starting the fires. This water should be supplied beforehand through a heater when the plant is in operation.

Following is my method of banking fires. I do not push the live coals to the bridge-wall, but cover the fire all over with green coal (this is what we call banking fires flat) half an hour before shutting down, allowing the pressure in the boilers to drop 15 to 20 lb.; then I open the furnace doors wide and close the dampers and the ashpit doors. We close all valves but the stop valves. The pressure in the boilers varies only from five to ten pounds during the night. I claim that this method of banking fires saves the brick lining and also the boilers from sudden contraction and expansion in getting steam up before starting. Many firemen think that this method makes the fire hot to clean before starting, especially in summer. In the morning we open all dampers and push the fires back to the bridge-

wall. We then close the furnace doors and let the front of the fire burn down to the ashes, which takes from five to seven minutes; then we clean the fire, which is cool at the front. I believe this is a good method as it has proved so in this plant. PATRICK MOLLOY.

New York City.

Setting Heavy Machine Bases

A comparison of two methods of procedure in lining and leveling machinery shows the advantage of parallel shims over wedges as follows: Three motors (5000, 4000 and 3250 hp.) were required in a 40-in. blooming mill. The first was set by using shims and wedges, and it required three men six days to set the base. It was first lined up, then leveled with wedges, then lined again which necessitated leveling again, etc. The trouble was that when the base was jacked over for line, sliding on the wedges raised one side and lowered the other and sledging the wedges to level up threw the base out of line.

In setting the other two the following method was used, requiring one day for each base. All thicknesses of shims from $\frac{5}{8}$ in. to sheet tin were first secured. The base was raised with the crane and leveled on four piles of shims, no wedges being used. It was then lined up with hydraulic jacks and found to be still level. This made a saving on the two bases of ten days for three machinists, amounting to $198.

This method can be used on all machine bases, where they can be lifted with a crane or jacks.

Baltimore, Md. L. C. SCOTT.

Generator Wreck at St. Paul

It was with great interest that I read the description of the generator wreck at St. Paul on page 40 in the issue of Jan. 14 and the three probable causes of the wreck, but there is still another condition that might have produced the same results.

Since the six polepieces were of the bolted-on type, these bolts could become loose owing to the vibration, and when the short-circuit came on the generator it perhaps caused a polepiece to break away and take the other polepieces with it, wedging the rotating member until the shaft was twisted off.

Trenton, N. J. THOMAS F. MCELROY.

Protecting Safety Valves Against Tampering

A criminal act that might have caused a boiler explosion had it not been discovered by the night watchman or firemen makes me think that it is advisable to build a protection around safety valves, especially around the collieries, to avoid a similar occurrence.

One night two tramps entered a large coal-mine power plant and asked the firemen for permission to sleep there. As it was against the rules, they were refused, which made them mad. It appeared that they were would-be murderers and must have had some experience around boiler rooms, and as they went out they swore they would take revenge. Some time later in the night they returned, and finding the place unguarded, they tied an old carwheel on the lever of the safety valve and partly closed a 10-in. valve leading to the pump in the mine, expecting that the pumpman would call for more steam pressure. The pumpman thought that the steam was low, but did not bother calling up because the water in the sump was nearly all out.

Toward morning the watchman noticed that something had been done to the safety valve and called the attention of the firemen to it, and knowing that the carwheel was put there by some malicious person, they of course removed it. When the colliery started to work the following day, the large pump in the mine was stuck for steam and everybody was puzzled for a time until the trouble was located.

Plymouth, Penn. JOSEPH R. THOMAS.

A Dangerous Blowoff Connection

On reading the letter by W. W. Henry, on page 29 in the issue of Jan. 7, I wondered why engineers do not more often use the malleable flush bushing, if they use bushings at all. The ordinary cast-iron bushing is all right for low-pressure work, but should not be used in high-pressure steam work.

On one job where there was a 3-in. flange riveted to the boiler for a blowoff pipe and the contract called for 2½-in. blowoff piping, the contractor used a malleable flush bushing in the flange and 2½-in. pipe and fittings to finish up the work, and the boiler inspector passed it as satisfactory and safe. JAMES E. NOBLE.

Portsmouth, Ont., Canada.

I think W. W. Henry's criticism of the blowoff connection is well taken. However, he does not go far enough, for the 2½-in. connection to the boiler is not much stronger than the bushing, especially if there is any strain on the piping, as standard 2½-in. 8-thread pipe is so nearly cut away by the threads that it is the weakest of all piping we have. In this case as in nearly all others in which 2½-in. pipe is used, 2-in. would have answered just as well and made a better job.

This brings up a question I have had in my mind for a long time: Why do manufacturers insist on using odd-sized pipe connections where regular sizes would answer as well? A few years ago I ordered several large centrifugal pumps for irrigating. For one size their catalog specified 7-in. pipe connections. I asked them to furnish companion flanges for 8-in. pipe. I explained to them that 7-in. pipe could not be obtained anywhere short of the mills and that in 20 years' pipeline experience, I hadn't even seen a length of it; but it was necessary to send a man to their factory to get it done.

Another instance: A sawmill man came to a plant where I worked to borrow a 2½-in. nipple to repair a broken steam connection. Luckily, I had some oil wells just across the road from the plant, and I remembered having seen a piece of 2½-in. pipe on the lease—the only piece of 2½-in. pipe within miles—although there were hundreds of miles of other sizes. We had a pipe machine that cut all sizes from 1- to 6-in., so we cut him a nipple and sent him away rejoicing, as otherwise it would have meant a long trip to a machine shop

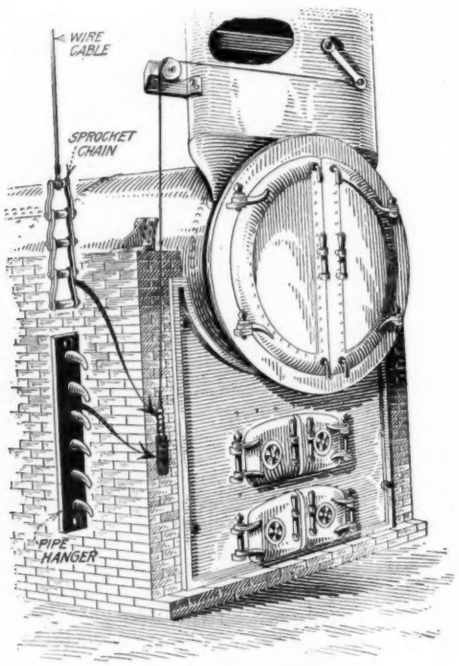
for him. I could cite other similar instances in which pipe of odd size was used where the regular size would have answered just as well. F. E. MYERS.

Charleston, W. Va.

Hand Damper Regulation

A convenient method of adjusting a hand-regulated damper is to use a piece of six-coil pipe hanger. The boiler front is tapped for two ⅜-in. capscrews at a convenient point, and the hanger is screwed in place inverted, as shown in the illustration.

A wire rope is run from the damper to a small pulley and a few links of sprocket chain or a metal ring attached to the loose end of the rope. In some cases the damper shaft is not in the center and the damper



A DAMPER CONTROL

will close itself when the rope is unhooked. Where the shaft is in the center of the damper, a weight on the end of the lever will close the damper when the cable is loosened. The various hooks permit of a wide range of control from closed to wide-open position.

Brantford, Ont., Canada. T. HENWOOD.

Carbon and Commutator Wear

Carbon manufacturers, as well as manufacturers of dynamo-electric machinery, have made numerous tests to determine contact resistances, friction losses, etc., of various carbons. While such tests are of interest, they contribute very little toward the real practical need; namely, a carbon that can stand high-current densities and high-sparking voltages with small wear.

In order to develop such carbons, it would seem essential to first make tests determining how the carbon wear is affected by current density, sparking voltage and peripheral speed. Present indications are that with many commercial carbons very appreciable densities can be used if there is no sparking voltage, while sparking voltages up to 15 or even 20 volts across the brush cause very little wear at certain speeds, if the current density is low enough.

More data along this line should be of great advantage to both the carbon manufacturer and the designing engineer. R. E. HELLMUND, Engineer,

Westinghouse Elec. & Mfg. Co.

East Pittsburgh, Penn.

Ice Formation in Ponds

I have just been reading a back number of *Power*, the issue of Dec. 31, 1918, page 951, and note that in the article entitled "Ice in Hydro-Electric Plant," the author in explaining the freezing of water makes the following statement: "When the temperature of the whole body reaches 32 deg., ice begins to form on the surface."

My understanding is that the process described continues until the entire body of water reaches the temperature of about 39 deg. F., at which point water is at its maximum density. The surface of the water then continues to cool, but the circulation stops as the cooler water is now of less specific gravity than that in the lower levels. Ice forms as soon as the surface water reaches 32 deg. F. and has given off its latent heat.

Indianapolis, Ind. FRED W. CLASMANN.

Threading a Short Pipe

The following "kink" may be of interest to others, so I am passing it on. To thread a pipe close to a bend or to thread a close nipple, reverse the dies in their sockets and use the stock in the reverse position but rotated in the right direction. This leaves no guide for the die, so to provide this use a short pipe of the size being threaded, having a good thread on one end, and insert it through the guide or follower and screw it into the die to act as a support. This can be held straight while the stock is turned and the thread started. When a few threads have been made, remove the guide pipe.

If plenty of oil is used, an excellent thread can be cut. Care should be taken to pull evenly on both handles or sides of the stock. HERBERT G. STODDARD.

East Orange, N. J.

Air-Compressor Efficiency Improved

It was discovered that the intake pipe of an air compressor had parted sufficiently to permit the entire air supply to be taken from a point indoors, below the cylinder. A thermometer placed at the break showed a temperature of 100 deg. F., while the temperature out of doors was 47. Since the loss in efficiency equals about 1 per cent. for each 5 deg. rise in temperature of the air supply, it will be seen that the loss in this case was over 10 per cent.

This compressor carried a constant load, a smaller one taking care of variations, and after repairing the break an appreciable difference could be noticed in the load carried by the smaller machine.

Toronto, Ont., Canada. R. MCLAREN.

INQUIRIES OF GENERAL INTEREST

Motors and Lights on the Same Circuit—What are the objections to supplying electric motors and lamps from the same feeder provided they are of the same voltage? J. N.

The chief objection to this practice is that if the motors are started under heavy load, they will cause the voltage to drop to such an extent as to make the lamps fluctuate. The most satisfactory voltage for motor operation is 240 or higher, where lamps operate most efficiently around 120 volts. Consequently, if the motors are to be designed and operated at the higher voltage, the lamps must be operated in series groups, which to say the least is not satisfactory.

Effects of Voltage Increase on Power Transmitted—State the effects on the current, resistance, diameter and weight of wire resulting in the transmission of a given power load by increasing the voltage four times, the percentage of loss remaining the same in both cases. H. F. S.

Since the voltage is increased four times, the current will be decreased four times. The resistance of the conductors can be increased 16 times, which means that the cross-sectional area will be reduced by 16; consequently, the weight of the conductor will only be $\frac{1}{16}$ that on the higher voltage that it would be on the lower, and the diameter of the conductor will be reduced 4 times. The foregoing is possible in practice only where the insulation of the conductor is sufficient to withstand the increased voltage and the conductor has sufficient mechanical strength to meet the requirements of operating conditions.

More Wiredrawing of Steam With Earlier Cutoff—When earlier cutoff is obtained with a slide-valve engine by adding lap to the valve and advancing the eccentric, why is there more drop of the pressure during admission and more gradual cutoff, than with less advance of the eccentric? W. R. C.

Assuming that the engine shaft rotates at a uniform speed, the valve is moved at the highest velocity when the eccentric is at right angles with the eccentric rod, or neglecting angularity of the eccentric rod, the quickest movement of the valve in opening or closing and greatest opening would be obtained with no lap and no angle of advance. By advancing the eccentric and adding lap, the valve opens after it has passed the point in its travel where it has greatest velocity and is slowing down more and more as it nears the end of its stroke, and complete cutoff occurs when the valve has attained only the same velocity in its return stroke. Hence, the earlier the cutoff obtained by advancing the eccentric the slower and less the amount of opening, and the slower the movement of the valve as it closes, thus giving rise to wiredrawing of the steam during admission and more gradual cutoff.

Paralleling Discharge of Centrifugals—We operate two centrifugal units for supplying separate 16-in. service mains of a town and a mill water supply. The discharge of each centrifugal has a branch with check valve to each service main. It is found that both pumps cannot be made to discharge at the same time into the same main, as one will build up higher pressure than the other. Could not this trouble be overcome by removing the flaps from the check valves? H. A. T.

Closure of a check valve is an effect and not a cause of back pressure, and when a check valve becomes seated, somewhat greater intensity of pressure is required to raise the flap than that holding the valve to its seat, the difference depending on the design and size of the valve. To operate in unison, each pump must have a building-up capacity in excess of the margin necessary for opening the check valves, and to insure discharge from both centrifugals at the same time it is necessary to limit the discharge to the highest pressure that can be overcome by the weaker centrifugal, less the extra pressure required for opening the check valve on its discharge. The built-up pressure of either pump can be reduced to the selected standard by chopping down its discharge or by returning part of its discharge back to the suction. To save constant attention of an operator this can be accomplished by a discharge-pressure regulating valve, or by an automatically operated bypass valve.

Watts in a Three-Phase Circuit—In testing three-phase induction motors, we connect a single-phase indicating wattmeter in one phase, and then in one of the other phases; the sum of the two readings gives the total watts consumed. If all three phases are balanced, why could we not get the total watts by taking a reading in one phase only and multiplying it by 1.732? E. C. H.

Your statement that the sum of the wattmeter readings gives the total load in watts is only correct when the power factor is greater than 0.50. When the power factor is less than 0.50, the difference of the two readings gives the total watts. If the power factor is unity, the readings of a wattmeter connected in one phase and then in another of a balanced three-phase circuit would be the same, and the total power would be the sum of the two readings, or the reading of one multiplied by 2 and not 1.732, as suggested in the question. However, this can only be true for a balanced circuit having a constant load at unity power factor, since in every other case the two readings will not be the same value, and as stated in the foregoing must be added when the power factor is greater than 0.50 and subtracted when less. The constant 1.732 is used only to obtain the apparent watts in a three-phase circuit, which when circuit is balanced is $W = EI \times 1.732$ where W equals the total watts transmitted, E volts between terminals and I amperes per terminal.

Formula for Approximate Capacity of Pump—What is the derivation of the formula, $g = \frac{D^2LN}{294}$ for finding the number of gallons delivered by a pump? R. O. J.

In the formula quoted,

g = Number of gallons pumped per minute;
D = Diameter of plunger or piston in inches;
L = Length of stroke in inches;
N = Number of single strokes per minute.

The plunger or piston displacement in cubic inches per minute would be area of piston × length of stroke × number of single strokes per minute, or $D \times D \times 0.7854 \times L \times N$, and as one gallon equals 231 cu.in.,

$$g = \frac{D^2 \times 0.7854 \times L \times N}{231}$$

and dividing both numerator and denominator of the second term by 0.7854 gives

$$g = \frac{D^2 \times L \times N}{294.117}, \text{ usually written, } \frac{D^2LN}{294}$$

If N is taken to represent the number of revolutions of a single double-acting pump the result is to be multiplied by 2, and if N represents the number of revolutions of a duplex pump, which would be the same as two single pumps, the result must be multiplied by 4. It also must be borne in mind that the formula gives results larger than actual capacity of a pump, for it makes no allowance for reduction of capacity by slippage, and in double-acting piston pumps the displacement on one side of the piston is reduced by the presence of the piston rod.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Utilizing Waste in the Power Plant*

TO INCREASE the service capacity of power plants by utilizing the waste, it is first necessary to understand the term waste. As ordinarily used, it has several definitions, but in the present discussion it will represent the energy of generated power and labor that is lost by thoughtless labor, the lack of proper and systematic inspection or the want of thoroughness in design and distribution of the generated energy in all its component parts. The waste in power plants, especially in the average railway plant, will be found in two forms—wasted energy and wasted labor.

Wasted energy can sometimes be observed in the form of leaks, which may be easily found if looked for. However, even this saving can only be made after first locating and stopping the waste in labor. The first thing to look for in wasted labor is a way or method to get labor to read and think. It is useless for men to think always without reading, and it is just as deficient to read always without thinking. It has been said that a man who will read will be able to think out problems better than the man who rarely reads, as the reading man will have the added thoughts of his fellow workmen on his problems and will obtain suggestions that would never come to him in his daily work. No labor, clerical or mechanical, can do as efficient work with verbal orders as with written instructions, and the instructions should be illustrated when necessary to make the plan of their part complete and in harmony with the main working plan.

Utilizing the Waste Labor

If wasted energy is to be utilized to increase the power-plant capacity, it will be necessary to utilize the wasted labor first. This can be accomplished only by constant education. This education need not be by classes, such as the schoolroom, but should be thorough, first by keeping posted in a conspicuous place in all power plants a complete layout of all apparatus down to the smallest pipe lines for any service, as well as the wiring, and different colors to represent different transmission lines, for easy identification. This should be placed on a wall under a glass cover so that a man having any connection with the operation, repair, extension, reconstruction or inspection can know that his original instructions can be easily understood in detail by observation of the reference drawings.

With the continual change of men in power plants, the frequent extensions and renewals, there is rarely an employee that is sure of each and every detail of his own duty in handling his part of the work. The average new man receives a few verbal instructions from his immediate superior or from his predecessor and is left to work out his own salvation. If he is a student he will start to explore all parts of his operation from beginning to end and be sure that he understands when and where he will interfere with his colaborers. If not, he will cause considerable confusion, not only in his own work but with others.

When investigating a pipe line that has not been performing just as it should, how many have started out to find what the line was intended for originally, and before this information was obtained had to search several files and waste a lot of clerical labor as well as their own? If a diagram of the original and all extensions had been on the wall in a glass case, the information would have been available in a few minutes. Chiefs and superintendents will say, "The information is in my office." That may be true, but the men should have it continually before them to read and think about. It will not only encourage them, but make their hard problems so simple that they will be able to carry out work with less expense of time and damaged material than in any other way, and change in men will not cause the usual discord in the organization.

Labor, either executive or detail, cannot find wasted energy efficiently without complete information as to the designer's original plan and his estimate of detail results. With this information constantly before them, the workmen know what to do and can always make a more intelligent report as to results. Inspection, daily or periodical, can be made in far less time, and accurate information will be obtained that will further increase the employee's capacity to stop waste and convert it into capacity.

Wasted energy has been analyzed and talked of as much as any subject. Furnace and stack designs are usually given careful consideration, and where they have been neglected there are data available to correct the design and stop the waste.

Energy Wasted in Handling Coal

When considering losses it is surprising how much energy, both in labor and power, is wasted with every handling of coal. The coal dust that settles around a boiler room in a day, a month or a year gives a small indication. An easy estimate can be made by taking a given square area of space so it can be easily cleaned of all accumulated coal dust periodically and the accumulation weighed. On top of boilers the coal dust is, in many cases, inches deep. Of course this represents only a small percentage of the coal, but it takes such small effort to prevent this waste. A little water sprinkled on the coal when it is handled will stop the waste and the expense of cleaning it up. Some go to the other extreme; that is, they will waste a lot of water that has a value by putting so much on the coal that they stop up the drains with coal that is washed out of the pile. These thoughts direct the operator's mind to the necessity of handling coal as few times as possible and of dampening the coal when handling.

Daily inspection of the ashpile will give an indication of the amount of unburned coal. Water thrown on the ashes before inspection will make the unburned coke stand out prominently from the ash or noncombustible, giving something definite on which to start an investigation as to the cause of the waste.

When boiler settings are of brick construction, the outside walls should be covered with plastic cement which will fill up the pores or cracks in the setting, and all joints should be calked with fibrous insulating material which will prevent air infiltration. Regular inspection will be required to see that the cement is maintained intact. The walls of the setting should be thick enough and properly provided with insulation or air space to prevent the temperature of the outside brick from becoming excessive and causing abnormal heat loss by radiation. The top of the boiler should be covered with good insulating material and joined with the setting so that the expansion of the boiler will not open up the joints and let in air. Stopping waste at these points will materially increase the service capacity of the boilers. Metal boiler settings are not altogether free from air leakage and should be given the same careful attention. Stack and stack connections, as well as the connections between the boiler fronts and the settings, need watching to prevent air leakage.

Instruments Needed in the Power Plant

Grates should be selected for the kind and size of coal that is to be burned. The proper draft and the load for a given boiler setting and furnace condition may be determined by CO_2 instruments. Contrary to the general belief instruments of this kind can be used by other than highly trained technical men. There are draft gages on the market that can be read and interpreted by any fireman. There is a simple draft regulator that will maintain the position of the damper so perfectly balanced with the load that a recording steam-gage chart will look as though it were drawn with a pair of dividers. The instruments previously mentioned and a recording thermometer on the boiler feed-water lines are some of the instruments needed in any power plant if the wasted labor is going to be educated to know how to save the wasted fuel energy to increase the service capacity of the boiler plant.

*Abstract of paper read by Edmund Burke of the Crane Company, before the Western Railway Club, Chicago.

Periodical tests are frequently used as a basis to determine the operating conditions in the plant. Tests will tell the operating conditions under fixed loads and maximum capacity, and are usually made under ideal conditions by men who do not duplicate the performance every day in the year. The tests that will turn the waste of the plant into service capacity are daily records made by the operating force, so that they will have something to study, and educate themselves each day under the working conditions. After that periodical inspection is good if it results in constructive criticism rather than fault finding.

Boiler trimmings should be selected with care, and regular inspection of the pop valves, water-gage columns, blowoff valves and fuse plugs will stop possible wastes that would reduce the service capacity materially.

Special fittings in pipe lines should be avoided as much as possible. All turns in high-pressure piping should be long-radius bends. The weight of fittings and valves should be governed more by the mechanical strains from the piping than the pressure strains, as the latter are far more destructive. The most important things to be considered in steam-pipe line design are the correct size and the layout to take up all mechanical strains. Waste caused by neglect of these items is difficult to locate and will seriously handicap the operator by not permitting flexible operation.

Few stop to consider the amount of money involved or loss of capacity caused by the small steam leaks around the power plant. The accompanying data offer a fair guide:

LOSS OF STEAM BY LEAKAGE

Gage Pressure	Loss of Steam Lb. per Hr. per Sq.In. of Leak	Cost of Loss per Month at 30c. per 1,000 Lb. for Steam
60	3,918	$846
75	4,676	1,010
100	5,925	1,280
120	6,936	1,498
140	7,932	1,713
150	8,787	1,898

Divide quantities in the table by the area of the leaks and the loss in any particular plant will be approximated. It will not require many leaky valve stems and few leaks around steam joints to make up a square inch of opening through which steam is flowing from the boiler to the atmosphere.

Numerous other wastes might be mentioned. The most important and the basic principle to correct all waste is periodical inspection and reports made out on a basis of educational development for the operators handling the equipment.

Biggest Annual Banquet of the W. S. E.

Jan. 22 was the date of the annual banquet of the Western Society of Engineers. It was held at Hotel Sherman, Chicago, and as the present year will see the fiftieth anniversary of the founding of the society, it was fitting that the attendance (465) should be the largest in the history of the organization. An excellent dinner interspersed with "ensemble" singing and an interesting program relating to the engineer's work in the war made up an enjoyable and profitable evening.

At a short business session preceding the speakers of the evening, B. H. Peck, electrical engineer of the State Public Utilities Commission, Springfield, Ill., was awarded the Chanute medal for the best paper presented to the society during the year. Announcement was also made of the award of the Alvord medal to Herbert C. Hoover, who had been chosen previously by a committee of the society as the engineer who had done most for the comfort and well being of humanity.

Charles B. Burdick, retiring president, recalled the fact that the fiftieth anniversary of the society was at hand and reviewed briefly the progress in engineering that had been made during the life of the organization. He said that one of the great aims of the society had been to promote engineering education. The one who prepares information for others benefits himself most. Technical discussion is of inestimable value in keeping up-to-date with the progress made in the profession. An engineer's best asset is to be well and favorably known and the society gives him the opportunity. The society should try to increase the compensation of engineers. Anything approaching trade union ism cannot be considered, but efforts to place engineers in public positions requiring engineering training and to insure good salaries are justified. Service could also be extended by helping to relieve unemployment among engineers.

In national affairs the engineer needs one mind and one voice. Reference was made to the movement originated by the four great founder societies in New York and of the invitation to membership extended to the Western Society and all local engineering associations of good standing.

Last year was a hard one, owing to the large number of engineers going into service. The loss of membership was excessive, but notwithstanding, the roll was increased more than during any year of the last decade. Creating new sections had been a great aid and it was the speaker's belief that provision for an industrial section would double the membership.

For the ensuing year the following officers were announced: President, A. S. Baldwin, vice president, Illinois Central Ry.; first vice president, Kempster B. Miller, consulting engineer; second vice president, W. M. Kinney, general manager of Portland Cement Association; third vice president, J. L. Hecht, mechanical engineer of Public Service Co. of Northern Illinois; treasurer, C. R. Dart, bridge engineer, Sanitary District; chairman of electrical engineering section, J. R. Cravath, consulting engineer; chairman of bridge and structural engineering section, G. A. Haggander, bridge engineer, C. B. & Q. R.R.; chairman of hydraulic, sanitary and municipal engineering section, Linn White, engineer of the South Park Board; chairman of mechanical engineering section, Fred J. Postel, engineer of the Board of Public Works, State of Illinois; chairman of gas engineering section, H. H. Clark, industrial gas engineer of Public Service Co. of Northern Illinois; trustee for three years, E. T. Howson, Western editor, *Railway Age;* trustee for two years, W. W. Deberard, Western editor, *Engineering News-Record;* trustee for one year, O. F. Dalstrom, bridge engineer, C. & N. W. Ry.

A. S. Baldwin, the incoming president, expressed the realization that the honor carried with it serious responsibilities and said that a disturbed condition existed throughout the whole world. It was reflected in all branches of society. Among engineers it was evident in the movement of the four founder societies to better conditions and to keep abreast of progress. Affairs of engineers were at flood tide. Never before had their ability been so widely recognized. They must now turn from war to work for the benefit of humanity. Those who had stayed at home now had exceptional opportunity to further the interests of the society and by doing so could do more for the profession than in any other way. In the coming year there should be unlimited opportunity for progress and all were requested to coöperate and join in the march forward.

Dr. E. H. Lewis, introduced as toastmaster, called upon Brig. General J. J. Morrow, Chief of Engineers, First Army, American Expeditionary Force, for the first address of the evening. The speaker told of the preparatory work in France and the accomplishments of the engineers while with the army, particularly in the Verdun Sector. He outlined the organization and enumerated the tasks and some of the experiences the engineers had while in service. On the whole the American engineer as a soldier, he said, was splendid, but due to the short period of training there were indications of a lack of discipline, a lack in knowing how to take care of things and a lack in accuracy of doing exactly what they were told to do. For the characteristic last named it was worth while for every engineer in civil life to develop and fit himself for military service. There had been also some difficulty in switching from the civil viewpoint of cost to the military idea of speed.

The final speaker of the evening was R. A. White, Chicago's famous travel lecturer, who gave an illustrated address on "War Conditions on the Western Front." The things he saw on the battlefield and the impressions he carried back were of exceptional interest.

Convention of Marine Engineers

The Forty-fourth annual convention of the National Marine Engineers' Beneficial Association was held at Buffalo, N. Y., during the week beginning Monday, Jan. 20, with headquarters at the Hotel Statler. There were 90 delegates present, representing 161 votes. They came from all parts of the United States and its possessions, including one each from Panama and Honolulu.

At the opening session on Monday morning the delegates were addressed by Mayor George S. Buck, who gave a brief, but interesting, history of the City of Buffalo, and cordially welcomed the convention. National President William S. Brown thanked the mayor for the nice things he said of the marine engineers and assured him that the address was doubly appreciated as the delegates were aware of how valuable the time of the mayor was.

Tuesday morning the delegates listened to an interesting talk by Mrs. August Molter, of the Women's Trade Union League, upon the aims and objects of that organization. William Kennedy, a charter member of the Cleveland Association No. 2, who has for 44 years been in active service for the uplift of the M. E. B. A., addressed the Tuesday afternoon session and was greatly appreciated.

The report of Treasurer Jones shows that the association is upon a firmer financial basis than ever before in the history of the organization. The increase in membership during the year 1918 was upward of 2500. During the week a charter was issued to Ocean Association No. 99, composed of deep-sea engineers.

A vote of thanks was tendered to the local association for its generous program of entertainment. There were many features of entertainment. On Monday evening there was a smoker at Elmwood Hall; on Tuesday evening the convention visited Shea's vaudeville theatre; on Wednesday there was a grand ball at Elmwood Hall, at which the attendance was fully 2000; Thursday morning a trip was made to Niagara Falls. All of the above were under the auspices of Local Association No. 1.

On Friday morning the convention, as guests of Mayor Buck and Fire Chief Murphy, enjoyed a trip around the harbor on board the fire tug "Gratten." On Thursday evening the National Marine Engineers' Supplymen's Association gave an entertainment and banquet at the Hotel Statler. Altogether the convention was voted as being among the best the M. E. B. A. ever had.

Early in the week the delegates elected national officers as follows: William S. Brown, president; John S. Purdie, first vice president; William H. Hyman, second vice president; Ed. C. Killian, third vice president; George A. Grubb, secretary; Albert L. Jones, treasurer. The executive committee comprises William S. Brown, Charles S. Follett, William T. Garrett, Robert L. Goelet, Ed. C. Killian, Charles M. Sheplar.

The newly elected officers of the Supplymen's Association include: J. J. Cizek, The Leslie Co., president; Andrew Lauterbach, The Lunkenheimer Co., vice president; Charles A. Wilhoft, New York Belting and Packing Co., secretary-treasurer.

The selection of the next convention city is left to the discretion of the executive committee to be decided upon in July next.

Foreign Trade Promotion

Previous to the war and owing to the conditions existing in the mercantile marine, comparatively few of the manufacturers of this country sought foreign markets and those who did held to a rigid system of credit protection. In Latin America an erroneous impression prevailed as to the integrity of America's business methods. But the war changed these conditions with the closing of the markets of Europe, and our trade with the twenty countries of South America increased from $750,000,000 in 1913-14 to $1,750,000,000 in 1917-18.

Our larger banking institutions, principally in New York City, established branches in all the countries of South America and the people of these countries have come to appreciate the service offered them by our financial institutions. Thus we are today in a position to compete as never before for this desirable business. For those interested in foreign-trade expansion the Bureau of Foreign and Domestic Commerce of the Department of Commerce has evolved an elaborate plan of information regarding export business, and is prepared to furnish data as follows:

Foreign Tariffs — Information concerning foreign tariff and customs laws and regulations, commercial policies of foreign countries, foreign trademarks and patent laws, embargoes and import prohibition, and foreign consular regulations.

Research — Supplies information on import and export statistics of all foreign countries, foreign sources of supply of raw materials, translating, and researches in all phases of foreign trade.

Statistics — Supplies information regarding import and export statistics of the trade of the United States with all countries. These statistics are furnished in ten-day, monthly, quarterly and yearly periods.

Far East—Information regarding ports and transportation facilities, investment opportunities, mineral resources and their development, and the markets for cotton goods, wearing apparel, railway equipment, motor vehicles, shoes and leather, etc.

Latin America — Information concerning markets for American products, regulations for guidance of commercial travelers, trade conditions in Latin America, specific openings for American exports, and concerns which might act as representatives of American exporters.

Correspondence — Furnishes American exporters information on markets in foreign countries, including advice on methods of packing, financing export shipments, sources of foreign credit data, lists of importers abroad, and names of domestic manufacturers.

Editorial—Makes available to the business public, through publications and indexes, information on commercial and industrial conditions in all parts of the world.

District Offices—Miniature bureaus at New York, Boston, Chicago, St. Louis, New Orleans, San Francisco and Seattle. Recognized centers for reliable information regarding domestic and foreign trade. Render special service to foreign buyers seeking goods in the United States, and adjusting trade differences.

Commercial Attaches—Located in the principal capitals of the world, furnish first-hand information and advice on banking, commercial, industrial and investment conditions abroad.

Special Agents—Technical trade investigators who study foreign markets for specific American commodities, also assist American manufacturers and exporters to establish satisfactory trade relations with particular foreign importers.

Trade Commissioners — Men with commercial and economic training who study general trade conditions abroad, with particular reference to increased sale of American products, supplying the raw materials necessary in American industries, etc.

Flywheel Explosion in St. Louis

In a rolling mill operated by the American Car and Foundry Co., in St. Louis, a flywheel exploded, damaging the building in which it was located and several adjacent buildings, the property damage totaling about $3000. Fortunately, no one was injured. The flywheel was 9 ft. in diameter, with an 8 x 8-in. rim section and was bolted to the crank shaft in halves. The engine to which it belonged is of the old-fashioned throttle-valve Buckeye type, running 120 r.p.m., with cylinder dimensions 12 x 30 in. It was belted to a lineshaft from which a set of blowers and other auxiliary apparatus were driven.

The explosion can be traced to no definite cause. At the moment of its occurrence the chief engineer was examining a shearing machine remote from the engineroom. He heard two preliminary muffled reports, as of a powder blast, followed instantly by the loud crash of the disrupting wheel, but he observed no irregularity in the running of the shafting. The governor was found in working order, and the belt which drove it was intact.

Obituary

Abram T. Baldwin, president of the Precision Instrument Co. of Detroit, Mich., died on Jan. 8.

Burt O. Gage, superintendent of the Warren (Mass.) Steam Pump Co., widely known as an inventor and pump expert, died at his home in Warren, Mass., Jan. 9, after a few days illness, of bronchial pneumonia. He was in his 76th year. He had been associated nearly all his life with the pump industry, entering the employ of the Knowles & Sibley Co., manufacturers of steam pumps, in 1867. For about forty years he was associated with this concern and its successors, the George F. Blake Manufacturing Co., of Warren and Boston, during which time he patented many useful and practical ideas in pumping machinery. In 1905, he became associated with the Warren Steam Pump Company, as superintendent. He had travelled extensively throughout the country, having charge of many water-works installations. At the time the cruiser "New York," now the "Rochester," was being planned, Mr. Gage helped to successfully develop a vertical type of pump occupying small floor area and known today in the pump trade as the vertical twin air pump. This type of pump is still in successful use on naval vessels. After becoming connected with the Warren Steam Pump Co., he invented a valve gear for direct-acting single pumps. He was also the originator and patentee in the use of monel sheets as pump liners.

Personals

Charles C. Enderle, who has been in the engine sales department of the Ball Engine Co. for some years, is now in charge of the Philadelphia district, with offices at 621 Commercial Trust Building, Philadelphia.

Herbert W. Gledhill, who was formerly sales engineer at the Philadelphia office of the Shepard Crane and Hoist Co., has been made district manager of that office, with Glenn Rumsey and Leland Woodworth as assistants.

Charles R. Emerson has been appointed general sales manager of the Foster Engineering Co. He was formerly manager of the company's Boston office for two years and manager of the Philadelphia office for the last six years.

Captain Edward E. Ashley, Jr., for many years consulting mechanical and electrical engineer for Starrett & Van Vleck, Architects, New York City, has resigned his commission in the Air Service of the United States Army, to accept appointment as sales engineer of the Mercury Manufacturing Co., Chicago, manufacturers of electrically-driven tractors for use in connection with industrial haulage systems.

Engineering Affairs

The American Association of Engineers had the St. Louis Chapter installed at a banquet at the Planters Hotel on the evening of Jan. 18 with about 150 members enrolled.

Liberty Association No. 15 of the National Association of Stationary Engineers, which was formerly the First German Association of Stationary Engineers of Cincinnati, Ohio, is doing good work, as its educational program for the coming season shows: On Jan. 25, J. W. Fowler will speak on "Flue Gas Analysis and Its Relation to Boiler Efficiency;" Feb. 8, "Powdered Coal as Furnace Fuel," by Theodore Nielander; Feb. 22, "Steam Jet Ash Conveyors," illustrated with lantern slides, by William E. Muse; Mar. 8, "Ventilation and Heating of Buildings," by A. M. Robinson; Mar. 22, "Care of Electrical Equipment," by Charles F. Kleine; Apr. 5, "Power Plant Efficiency," by R. W. Parry; Apr. 19, "Sawdust, Offal and Tanbark as Fuel," by Judson Pratt. All meetings will be held in the hall of the association, 519 Main St., at 8 p. m.

Miscellaneous News

The Indiana Power and Water Co., Vincennes, Ind., will expend approximately $150,000 for improvements. It is the intention to supply power and light to the Illinois oil fields to the west of Vincennes by stringing three 33,000-volt wires across the Wabash River, spanning the stream from one of the main streets of Vincennes. The power is to be sold to the Central Illinois Public Service Co. which is to supply territory near Lawrenceville, Brideport and Stoey, Ill., with power and light and to provide residents along the proposed route with power and light as well.

The Bureau of Labor of the United States Fuel Administration will continue to function until the proclamation of peace, it was announced recently.

Under an agreement published July 23, 1918, all labor questions pertaining to the coal-mining industry were placed definitely under the jurisdiction of the Fuel Administrator, this arrangement having the sanction of the Secretary of Labor and of the United Mine Workers of America. The agreement included the provision that any dispute failing of settlement between the parties at interest must be submitted to the Fuel Administration for final disposition without stoppage of work.

Fatal Tube Failure in St. Louis—At the Purina Mills, St. Louis, Mo., on Jan. 15, a tube failure in a 250-hp. water-tube boiler resulted in the death of two men. The engineer, who was standing in front of the furnace, was almost instantly killed, and the fireman was so badly scalded that he died two days later in the hospital. The boiler was equipped with 3½-in. tubes. The accident resulted from the wearing away of the external surface of the tube by attrition. The tube split open for a length of about 24 inches. As the result of an inspection following the explosion, the entire set of tubes was renewed, many of them having been found worn to less than ¼ in. thickness. The boiler was installed about twenty years ago, and had been run continuously with the original set of tubes. It was practically free from scale, and there was no evidence of tube-corrosion, neither internally nor externally.

The United States Shipping Board wants at once 500 American seamen of more than two years' experience on deep water, and five hundred mechanics with engineering experience, to be trained as deck officers and marine engineers respectively, for the Merchant Marine. The seamen will be trained in navigation at twenty-one free navigation schools maintained by the Board, and the mechanics at free courses in technical colleges or at the special marine engineering schools of the Board. Stationary and locomotive engineers, machinists, who have worked on marine engines and marine oilers and water tenders will be accepted for the engineering courses. When the sailors have completed a six weeks' course of study and the engineers a month's course, they will be examined for licenses as third mates and third assistant engineers respectively, and sent to sea. Engineering schools are maintained at Massachusetts Institute of Technology, Cambridge, Mass.; Pratt Institute, Brooklyn; Seaman's Church Institute, New York; Dickinson High School Building, Jersey City; The Bourse, Philadelphia; Armour Institute, Chicago; Case School of Applied Science, Cleveland; University of Washington, Seattle; University of California, Berkeley, and Tulane University, New Orleans. The navigation schools are at the chief coast and lake ports, and their addresses will be furnished applicants by the U. S. Steamboat inspectors, or by the Sea Service Bureau agents of the Shipping Board at the various ports. General information about the schools will be furnished by Henry Howard, Custom House, Boston.

Trade Catalogs

Ross Power Equipment Co., Indianapolis, Ind., has issued its Bulletin No. 9, which supersedes previous bulletins, and gives a partial list of its available new and used equipment for sale, for steam and electric plants.

Ladew Leather Belting. Edw. R. Ladew Co., Inc., New York City. An attractive and interesting 108-page catalog, 6 x 9 in., fully illustrated, with several pages devoted to a discussion of belt engineering and belting economics. A free copy may be had upon request.

Foxboro Power Plant Instruments. The Foxboro Co., Inc., Foxboro, Mass. Bulletin 115. A condensed bulletin briefly covering the company's instruments manufactured especially for use in power plants. A copy may be had free upon request.

New Construction

PROPOSED WORK

Mass., Montague City—The Turners Falls Power & Electric Co., Turners Falls, plans to install another unit in its power house here. Plans are also being prepared for a 44 x 48 x 55 ft. concrete, steel and brick addition to its present building and for raising concrete canal walls about 2 ft. for distance of 5000 ft.

Mass., New Bedford—The Board of Education will install a steam heating system in the 2 story, 117 x 155 ft. school building which it plans to build on Emery St. Total estimated cost, $185,000. F. C. Brown, Chapman Bldg., Arch.

Conn., Hartford—Libby, McNeil & Libby, 252 Asylum St., will soon receive bids for the construction of a 3-story, 50 x 112 ft., cold storage plant on Edwards St. Estimated cost, $60,000. Philip Larmon, c/o Swift & Co., Union Stock Yards, Chicago, Ill., Engr.

Conn., New Britain—The State plans to install a vacuum heating system in the 2 story, 64 x 110 ft. school house which it plans to build on Camp St. Total estimated cost, $100,000. C. D. Hine, Hartford, State Supt. Davis & Brooks, Lewis and Gold St., Hartford, Arch.

Conn., Willimantic—The State plans to install a steam heating system in the 3-story, 46 x 114 and 30 x 46 ft. dormitory which it plans to construct on Valley St. Total estimated cost, $150,000. C. D. Hine, Hartford, State Supt. Davis & Brooks, Lewis and Gold Sts., Hartford, Arch.

N. Y., Albion—The Directors of the State Home for Refuge for Women, Albany, have applied to the State Legislature for an appropriation of $10,000 for installing new heating line and equipment and $10,000 for covering of steam lines and mains at the home here; $30,000 for building a cold storage and ice making plant.

N. Y., Bath—The Directors of the New York Soldiers & Sailors Home have applied to the State Legislature, Albany, for an appropriation of $24,000 for new electric construction, consisting of a new A.C. generator, engine, switchboard, voltage regulator, etc., new underground feeders, and transformers; also $89,200 for new heating construction, consisting of 4 new boilers, new underground heating, line, hot water plant, etc.

N. Y., Brooklyn—The Directors of the Williamsburg Hospital, 342 Bedford Ave., will install a steam heating system in the 7-story, 126 x 150 ft. hospital which they plan to build on South 9th St. and Driggs Ave. Total estimated cost, $350,000. Helmle & Corbett, 190 Montague St., Arch.

N. Y., Central Islip—The State Hospital Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $80,000 for building an addition to the store house and refrigerating plant and $10,000 for 3 new boilers and piping at the Central Islip State Hospital.

N. Y., Hudson—The Directors of the N. Y. State Training School for Girls have applied to the State Legislature, Albany, for an appropriation of $48,000 for building a refrigerating plant and store house.

N. Y., Industry—The Directors of the N. Y. State Industrial School have applied to the State Legislature, Albany, for an appropriation of $20,000 for improvements to heating system.

N. Y., Iroquois—Bids will be received until Feb. 15 by W. Hunt, Pres. of the Bd. of Managers, Thomas Indian School, for installing refrigerating equipment. Estimated cost, $10,000.

N. Y., Jay—The Au Sable Forks Electric Co., Inc., Au Sable, plans to build an electric-light plant here. Estimated cost, $25,000.

N. Y., Newark—The Directors of the New York State Custodial Asylum for Women have applied to the State Legislature, Albany, for an appropriation of $10,000 for installing a low pressure heating main through the tunnel.

N. Y., New York—C. Muller, Rockaway Park, will install a steam heating system in the 4 story, 100 x 200 ft. garage which will be built on West Dykman St., west of Sherman Ave. Total estimated cost, $100,000. Joseph T. Powers, 220 Larkei St. Rockaway Park, Arch.

N. Y., Ogdensburg—The State Hospital Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $65,000 for increasing the boiler capacity in the St. Lawrence State Hospital.

N. Y., Ossining—The State Prison Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $20,000 for installing new refrigerating apparatus in Sing Sing prison.

N. Y., Poughkeepsie—The State Hospital Commission, Capitol, Albany, will install one 30 h.p. motor and one pump in the Hudson River State Hospital, in connection with the alterations and additions which it plans to same. Total estimated cost, $40,000. L. V. Pilcher, State Arch.

N. Y., Rochester—The State Hospital Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $72,000 for building an addition to power house and $35,000 for installing an automatic sprinkler system in the Rochester State Hospital.

N. J., Newark—The Board of Education plans to build a power house in connection with the 4 story, 200 x 200 ft. Vocational School for Boys which it plans to build on Sussex Ave. and 1st St. Total estimated cost, $500,000. J. H. and W. C. Ely, Firemans Bldg., Arch.

N. J., Newark—Peter Hauck, 85 Clifton Ave., will install power equipment in his factory for the manufacture of nut butter. Lockwood Greene & Co., 101 Park Ave., New York City, Engr.

Penn., Avella—The Washington County Dairy & Produce Co. plans to build a 20 ton ice plant and install electric power generator in order to furnish light for the city of Avella. The company is in the market for engines and refrigerating machinery. J. A. Taylor, Mgr.

Penn., Mauch Chunk—M. G. Prutzman, Court House, plans to build an electric light plant.

D. C., Georgetown—The Fussell-Young Ice Cream Co., 12th and V St., has had plans prepared for the construction of a 40 x 60 ft. power house. Estimated cost, $25,000. Van Rensaeler H. Green, 154 Nassau St., New York City, Engr.

D. C., Washington—The International Association of American Machinists, 9th St. and Massachusetts Ave., plans to install a steam heating system in the 5 story, 68 x 100 ft. office and loft building which it plans to construct on 9th St. and Mt. Vernon Pl. Total estimated cost, $150,000. Melburn, Heister & Co., Engr.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until Feb. 17 for installing machinery, equipment and piping for the power plant here; Specification No. 3328. Estimated cost, $125,000.

Ga., Lyerly—J. S. Owings has purchased the Sarling Mill property here and plans to build an electric light and power plant.

Fla., Bunnell—The city voted in favor of a $15,000 bond issue for the construction of an electric-light plant. Address the Mayor.

Ala., Selma—The city plans to build an electric light plant. Louis Benish, Mayor.

Ohio, Cleveland—The Clover Meadow Creamery Co., Crawford Rd. and Hough Ave., will install steam heating system, refrigeration plant and two 60 h.p. boilers, etc., in the 2 story creamery which it plans to build at 1827 East 55th St. Total estimated cost, $60,000. Walter G. Caldwell, 1206 Williamson Bldg., Arch.

Wis., Ladysmith—The Ashland Light, Power & Railway Co. plans to build a hydro-electric plant on the Flambeau River. Estimated cost, $1,750,000. L. E. Meyers, 53 West Jackson Blvd., Chicago, Ill., Engr.

Iowa, Cherokee—The Sache & Bunn Co., 322 3rd St., will install a boiler and heating and radiation systems in the 2 story, 32 x 80 ft. storage building which it plans to build. Total estimated cost, $30,000. Beuttler & Arnold, 610 Security Bldg., Sioux City, Arch.

Minn., Cloquet—The Board of Education will install a ventilation system and steam heating equipment in the 3 story, 65 x 196 ft. school which it plans to build on Main St. Total estimated cost, $140,000. Croft & Boerner, Lansdale Bldg., Duluth, Engr.

Minn., Duluth—The Protestant Church Trustees, Morgan Park, will install a complete steam heating plant and mechanical ventilation system in the 2 story church which they plan to build on Commonwealth Ave. Total estimated cost, $100,000. Gorman & Jenssen, Exchange Bldg., Engr

Minn., Little Falls—The Little Falls Power Co., Little Falls, plans to extend its transmission lines into Aldrich to supply the village with light. T. C. Gordon, Mgr.

Minn., Little Fork—The Little Fork Light & Power Co., Inc., plans to build an electric light and power plant. E. Polkinghorne is interested.

Minn., Mountain Iron—The Board of Education will install a steam heating system with temperature control, also electric equipment, in the 2 story, 134 x 156 ft. grade school which it plans to build in Leondas Twp. Total estimated cost, $175,000. H. E. Mitchell, Secy.

Minn., Mountain Iron—The Board of Education plans to install a steam heating system and electrical equipment in the 3 story, 145 x 173 ft. technical grade school which it plans to build on Main St. Total estimated cost, $700,000. H. E. Mitchell, Secy.

Kan., Oswego—The city plans to take over and rebuild the plant of the Oswego Light, Power & Supply Co., and install electrical equipment to do the pumping of the city water system. J. M. Rings, Mgr.

Mo., Macon—The city voted in favor of a bond issue for $45,000 for water-works and electrical improvements.

Mo., Sikeston—The city plans an election in April to vote on a bond issue to build an electric light plant. Address the Mayor.

Tex., San Antonio—The Construction Division of the War Department, Washington, D. C., has authorized the enlargement of the refrigerating plants at Camp Travis and Fort Sam Houston Hospitals. Estimated cost, $10,000. Work will be done under the direction of Major F. G. Chamberlain, Construction Quartermaster.

Okla., Marietta—The city plans an election soon to vote on a bond issue for improvements to the water-works and electric light plant.

Cal., Bakersfield—The Southern California Edison Co., 301 South Broadway, Los Angeles, has had surveys made by E. F. Prouse, Asst. Engr., for a large hydro-electric plant, to include construction of a dam, in Hern River Valley. Estimated cost, $10,000,000. W. Dennis, Ch. Engr.

Cal., Tulare—The Mt. Whitney Power & Electric Co., 215 West Main St., Visalia, plans to expend $60,000 for extending lines to farmers pumping plant; $1700 for converting lines in Tulare from 2 phase, 6000 volts, into 3 phase, 11000 volts; also $5000 to install one 500 k.w., 11,000 volt transformer and one300 k.w., 200 volt transformer in the Tulare substation. F. G. Hamilton, Supt. West Div.

N. S., Antigonish—The Town Council plans to rebuild its electric light plant which was destroyed by fire. Estimated cost, $40,000.

N. B., Sussex—Charles T. White & Son, Ltd., is in the market for a 3-phase alternating generator, 1000 light capacity.

Ont., Alvinston—The Hydro-Electric Commission of Ontario, University Ave., Toronto, is receiving bids for remodeling the electric light plant and system, consisting of new steam boilers and interior and exterior wiring. F. A. Gaby, Engr. Noted Jan. 14.

Ont., St. Marys—The St. Marys Wood Specialty Co. is in the market for hydro motors, 10 to 30 h.p.

Ont., Toronto—The Dominion Shipbuilding Co., foot of Bathurst St., plans to build a boiler house and make other improvements to its plant.

Sask., Gravelbourg—Sam Chevrier plans to install an electric light plant. Estimated cost, $40,000.

Sask., Melfort—The Saskatchewan Co-operative Creameries plan to build a cold storage plant and creamery and are in the market for machinery and equipment. James Rutledge, Mgr.

Sask., Saskatoon—The City Council plans to build an addition to its water-works and is in the market for turbines, machinery and other equipment for the plant. Andrew Leslie, Clk.

CONTRACTS AWARDED

Ariz., Ajo—The Ajo School District No. 15 received lowest bid for installing plumbing and steam heating system in the proposed 2 story school, from Horrall & Bellas, 523 West Van Buren St., Phoenix. Estimated cost, $14,996.

N. S., Halifax—The Dominion Government, Ottawa, Ont., has awarded the contract for the construction of a power house and laundry for the Military Hospital at Camp Hill, to Rhodes, Curry Co., Ltd., Amherst. Estimated cost, $210,565.

THE COAL MARKET

BOSTON—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All rail to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

NEW YORK—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

PHILADELPHIA—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

CHICAGO—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.30		2.75—2.90

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

ST. LOUIS—Prices per net ton bituminous coal f.o.b mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		80c. per ft.
Common, 2½-in.		30%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.55	$0.40	$0.30

Steam—Discounts from List

First grade..... 25% Second grade.....35% Third grade.....40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 30%
Standard..... 40%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—50% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING

Pipe Size	Standard List Per Lin.Ft.
1-in.	$0.27
2-in.	.36
6-in.	.80
4-in.	.60
3-in.	.45
8-in.	1.10
10-in.	1.30

BLOCKS AND SHEETS

Thickness	Price per Sq.Ft.
½-in.	$0.27
1 -in.	.30
1½-in.	.45
2 -in.	.60
2½-in.	.75
3 -in.	.90
3½-in.	1.05

85% magnesia high pressure..... Llist

For low-pressure heating and return lines { 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5½	6.9	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4.1	3½	5½
Gear	4½	9	4½	9.5	8	9
Car journal	22(gal.)	21 (gal.)	3½	4.5	5	8

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1.49	$1.28	$1.90	$1.30	$1.65	$1.26
5-gal. cans	1.74	1.38	2.00	1.40	1.86	1.35

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil		Dry and In Oil	
100-lb. keg	13.00	14.50	12.25	12.50	13.00		12.50	
25- and 50-lb. kegs	13.25	14.75	12.50	12.75	13.25		12.75	
12½-lb. keg	13.50	15.00	12.75	13.00	13.50		13.00	
5-lb. cans	.....	.....	14.25	14.00	15.00		14.50	
1-lb. cans	.....	.....	14.25	14.50	16.00		14.50	

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. carboys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	40%	45–5%	40%
Tinned	30%	45–5%	40%

Button heads, ½, ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York...$5.675 Cleveland...$5.15 Chicago...$5.67 Pittsburgh... 4.65

Coneheads, same sizes:

New York...$5.775 Cleveland...$5.25 Chicago...$5.77 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	37.50 at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	90.00 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL—Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	70.00	80.00	93.00	75.00	70.00
Commercial	42.00	40.00	21.50	22.00	15.00	25.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.50
Chicago	19.00	15.00

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel Inches	Steel Black	Steel Galvanized	Iron Inches	Iron Black	Iron Galvanized
⅛, ¼, and ⅜	47%	20½%	¾ to 1½	36%	20%
½	51%	36½%			
¾ to 3	54%	40½%			

LAP WELD

2	47%	34½%	2	29%	15%
2½ to 6	50%	37½%	2½ to 6	31%	18%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	43%	25½%	¾ to 1½	36%	21%
½	48%	35½%			
¾ to 1½	52%	39½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	45%	33½%	2	30%	17%
2½ to 4	48%	36½%	2½ to 4	32%	20%
4½ to 6	47%	35½%	4½ to 6	31%	19%

Stock discounts in cities named are as follows:

	New York Black	New York Galvanized	Cleveland Black	Cleveland Galvanized	Chicago Black	Chicago Galvanized
¼ to 3 in. steel butt welded	43%	27%	43%	26%	41.1%	26.1%
3½ to 3 in. steel lap welded	38%	29%	39%	23%	37.1%	23.1%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%.
Cast iron, standard sizes, 10% off.

BOILER TUBES — The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	37	3½ to 4½ in.	15½
2¼ to 3¼ in.	27	3 to 3¼ in.	+ 2
2¼ in.	20½	2½ to 2¾ in.	+ 4½
1¼ to 2 in.	16	2 to 2½ in.	+19½
		1¼ to 1¾ in.	+32

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$334	1¾ in.	$214
1¼ in.	274	2 to 2½ in.	184
1½ in.	264	2¾ to 3¾ in.	174
1¾ in.	214	4 in.	194
		4½ to 5 in.	214

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$222.00
No. 12 solid	135.00	170.00	211.00	290.00
No. 10 solid	185.00	235.00	255.00	325.00
No. 8 stranded	235.00	325.00	345.00	450.00
No. 6 stranded	370.00	472.00	625.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	10%
Coils to 1,000 ft.	15%
1,000 ft. and over	

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
¼	.....	.....	$18.24	$19.38	$5.76	$6.12
⅜	$76.50	$81.60	18.24	19.38	6.72	7.14
½	101.20	108.10	24.00	25.50	9.60	10.20
¾	149.60	159.80	35.52	37.74	12.48	13.26
1	202.40	216.20	45.45	48.15	17.17	18.19
1¼	242.00	258.50	60.60	64.20	21.21	22.47
1½	325.60	347.80	111.11	117.70	28.28	29.96
2	514.80	549.90	181.80	192.60	40.40	42.80
2½	673.20	719.10	484.80	513.60	60.60	64.20
3	837.20	892.40	1,070.60	1,134.20	80.80	85.60
3½	1,013.70	1,079.10	1,237.25	1,310.75	101.00	107.00
4						

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ⅜ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅛	250	$0.05½	Coils, 55% Off.
¼	250	.06	Less coils, 40% off
⅜	250	.09	
½	200	.12	
¾	200	.15	
¾	150	.18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	.....
T. P. S. B.	.81	1.80	.....
D. P. D. B.	.78	2.10	.....
T. P. D. B.	1.35	3.60	.....
T. P. to D. P. D. B.	.90	2.52	.....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	28.40
No. 18 cotton parallel	25.00
No. 16 cotton parallel	32.00
No. 18 cotton reinforced heavy	35.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.00
No. 18 cotton Canvasite cord	29.00
No. 16 cotton Canvasite cord	35.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
450-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 30%
1-5th to standard package 40%
Standard package 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5.25 C
0-30 ampere, less than standard package	7.00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B— Watts	Plain	Frosted	No. in Package	Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$13.00	$16.00	$18.00	$32.00
12	16.70	18.80	22.00	36.85
10	23.52	26.10	29.10	50.60
8	31.00	36.40	40.20	70.10
6	.....	.....	62.00	.....
4	.....	.....	83.10	.....
2	.....	.....	122.40	.....
1	.....	.....	161.30	.....
0	.....	.....	189.68	.....
00	.....	.....	230.00	.....
000	.....	.....	282.40	.....
0000	.....	.....	345.50	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15.00	$19.00	$38.40	$21.00	$16.00	$33.00	$13.00	$17.40	$36.80
10	22.65	29.05	58.25	27.20	31.00	69.00	21.40	24.40	42.75
8	31.95	39.20	78.65	38.00	42.00	78.00	42.35	44.35	.....
6	54.40	58.10	.....	.....	65.00	130.00	64.60	74.60	.....
4	77.50	83.00	.....	.....	93.00	.....	101.75	106.05	.....
2	115.30	123.50	.....	.....	140.00	.....	151.50	.....	.....
1	150.05	161.20	.....	.....	182.00	.....	201.00	258.50	.....
0	.....	179.05	.....	.....	242.00	.....	276.00	285.00	.....
00	.....	243.35	.....	.....	290.00	.....	317.00	330.00	.....
000	.....	296.65	.....	.....	360.00	.....	417.00	428.50	.....
0000	.....	361.50	.....	.....	435.00	.....	516.00	516.00	.....

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	50c. lb.
No. 18 B.&S. regular 1-lb. coils	52c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%